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### The Effects of Experimentally Controlled Experience upon Recognition Responses

By

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Psychological Monographs: General and Applied

# THE EFFECTS OF EXPERIMENTALLY CONTROLLED EXPERIENCE UPON RECOGNITION RESPONSES[1]

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THE report presented in this monograph represents the accumulated evidence from the first four years of a continuing project of research in recognition. The emphasis in the series of experiments reported herein has been upon the effects of variations in the conditions of perceptual learning on the responses of recognition to ambiguous cues. In one or more of these experiments the learning factors of frequency, selective attention, reward, and punishment have been investigated in terms of their relationships to perceptual responding. The ambiguous cues to which the perceptual responses were made consisted of parts of the stimuli seen in previous learning trials.

There has been a good deal of interest in recent years in finding the relationship between certain aspects of past experience and various phenomena which are clearly perceptual or which are closely related to perception. A large proportion of the work in this area has involved studies with primary emphasis upon the effects of variations in experiential frequency upon perception. In some of these studies the past experience has meant the individual's personal history in his pre-experimental environment, while in others past history has implied certain experimentally controlled learning trials prior to some perceptual test. Thus, Howes and Solomon (1951) found that visual recognition threshold, as measured tachistoscopically in an ascending series, approximated a decreasing linear function of the logarithm of word frequency as tabulated by Thorndike and Lorge (1944). The obtained correlations between mean duration threshold and word frequency varied between $-.68$ and $-.82$, in separate determinations. The counts of Thorndike and Lorge were assumed to be estimates of the relative frequencies with which their subjects (*S*s) had encountered the various words. Attneave (1953) postulated that a high degree of familiarity with stimulus materials "may serve as a substitute for actual stimulation in the perceptual process" (p. 81). In his experiment *S*s were required to judge the relative frequency of occurrence, in English text, of each letter of the alphabet. He found that a power function provided a reasonably adequate fit for the points plotted on the basis of median judged frequency and actual frequency of occurrence of the letters in a sample of 10,341 letters from printed material. The correlation between log judged frequency and log actual frequency was .88.

Solomon and Postman (1952) emphasized that an individual *S*'s relative frequency of contact with units of English language is only crudely estimated by counts of printed material. Accordingly, in order to have better control of frequency, they experimentally manipulated the frequency with which *S*s used pronounceable nonsense words. Visual recognition threshold for words was reported as a negatively accelerated decay function of frequency of experimental exposure with zero frequency included in the analysis, and as approximately a decreasing linear function of the logarithm of frequency when the zero frequency was omitted. Arnoult (1956), more recently, exposed 10 random nonsense stimuli to *S*s at varying frequencies and then asked these *S*s to rate the same stimuli on a familiarity scale containing five points. He found rated

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familiarity of nonsense shapes a monotonic, negatively accelerated function of the experimentally controlled frequency of experience.

Besides the research on the effects of frequency on perceptual responses, there have been studies on the influence of such factors as deprivation, reward, punishment, set, meaning, avoidance training, and labeling upon perception. Thus, Sanford (1936) had *S*s give their interpretations of ambiguous pictures shortly before and shortly after a regular meal, and then counted the number of responses involving food and eating. He found many more food-related responses before as opposed to after the meal. Later, Sanford (1937) and Levine, Chein, and Murphy (1942) obtained results providing further confirmation of Sanford's hypothesis relating food deprivation and an increase of perceptual responses involving food. Proshansky and Murphy (1942) had *S*s estimate the lengths of intermediate lines, the weights of intermediate objects, and the extent of autokinetic movement, before and after long lines, heavy objects, and movement of a light to the right were rewarded while short lines, light objects, and movement of the light to the left were punished. Reward and punishment consisted, respectively, of giving 15 cents to and removing 15 cents from the *S*s. These *S*s showed a significant shift in their estimates in the direction of the rewarded stimuli.

Bruner, Miller, and Zimmerman (1955) found that errors of recognizing words, presented in conjunction with masking noises, decreased as knowledge of the set of possible alternatives increased. The effect was greater for short lists of words than for longer lists. Taylor (1958) gave *S*s preliminary training on nonsense syllables, such that one group saw only the syllables while the other group saw the syllables in association with pictures which presumably gave the syllables meaning. The tachistoscopic thresholds for the words were then determined, and she found that prior knowledge of the stimuli did lower thresholds, but meaning did not. Lazarus and McCleary (1951) conditioned the GSR to nonsense syllables by means of electric shock during a training period. Nonshocked syllables were also presented during this period. In later tachistoscopic trials they found the mean GSR for wrong responses higher when a shock syllable was shown than when a nonshock syllable was shown, indicating that *S*s can make "autonomic discriminations" even when they do not give accurate verbal reports. Finally, Hake and Eriksen (1956) found that the performance of *S*s on a recognition task was affected by the number of labels used in naming the actual patterns used in the task, but not by the number of labels used in naming the same patterns previously.

The experiments to be reported here fall in the general class of research aimed at determining the relationships between experiential and perceptual variables. The experiential variables in these experiments are frequency, reward, and punishment; while the perceptual variables involve responses indicating recognition of ambiguous stimuli. An experimental approach to evaluate and control the experience has been used.

Recognition has been assumed to be a classifying process where cues are used to make a set of decisions as to the assignment of a given stimulus object to a particular class. Binder (1955) and Bruner (1957) have adopted this approach in their theoretical presentations of the processes of recognition and perception, respectively. According to this viewpoint, a naming response designates a particular stimulus object as belonging to a class defined on the basis of common cues. Thus, when a person is confronted with the task of identifying an orange, he may use its size to rule out such response classes as "basketball" and "beach ball," and perhaps its shape to rule out "tangerine." One would predict, on the basis of this analysis, that, when an individual has learned to make discriminatory responses indicating recognition on the basis of configurations of cues, he can also identify objects on the basis of subsets of the configurations.

But, if the complete set of cues is necessary for unique discrimination, any reduc-

tion in information resulting from the availability of only a subset of all cues produces ambiguity. If a person catches only an instantaneous glimpse of a spherical object traveling through the air at high velocity, for example, we assume that his previous experience with full cue objects enables him to use the reduced cues for identification purposes. The cue "spherical," however, has been part of the complete set of cues of many objects, including tennis balls, golf balls, and oranges. The situation is ambiguous because of the limited information in the form of cues.

Ambiguity may also occur when too many cues are present, as, for example, in the case of reversible figures where the cues defining two or more objects are present in the stimulating situation. Thus, considering stimulus–object classes as defined on the basis of common attributes or cues, a stimulus situation may be called ambiguous when the entire set of cues available to an observer belongs to the attribute arrays of two or more such classes.

The tachistoscope produces ambiguity by presenting a stimulus object so rapidly that details are obliterated in the over-all blur seen by an observer. The cues available to the observer might have come from any number of different objects. And the faster the stimulus is presented, the more the blurring effect and the greater the ambiguity as a result of the larger number of stimulus objects from which the available cues could have come.

In the case of the Rorschach and similar projective techniques, ambiguous stimuli are used to assess various aspects of the life histories of individuals. An unstructured form, which has shape, color, and/or texture-like attributes common to many object classes, is presented to *S*s under instructions to specify what it looks like. Some may call a given blur a human, others a bear, and perhaps still others a dead eagle. Assuming no pathology on the part of the *S*, attributes of the blur may be characteristic of the objects in each of these classes. The attributes which would lead to clear differentiation among the classes are not available.

But what are the factors which lead to one response rather than another equally adequate one in an ambiguous situation? Which response, for example, would the person, who caught the quick glimpse of the object in the air, make if asked to identify the object. If he were standing on a tennis court, he would almost certainly call it a "tennis ball," unless, perhaps, there were an adjoining golf driving range. The response would therefore clearly be related to the frequency with which the various objects were previously experienced in the given context. Using the Rorschach and similar projective techniques, the clinician uses the responses of *S* to evaluate the latter's personality. The clinician is, explicitly or implicitly, assuming that the choice among the possible recognition responses of an individual to an ambiguous blot configuration is a function of the individual's previous experiences of reward, punishment, deprivation, frustration, and so forth. One person may have been frustrated in his experiences with women and give no responses dealing with femininity throughout his entire Rorschach protocol. Another may have been deprived sexually and report sexual symbols on every blot.

Much of the research reported above on the relationship between experience and perception has dealt specifically with the factors which influence responses to ambiguous cues (Levin et al., 1942; Proshansky & Murphy, 1942; Sanford, 1936, 1937; Solomon & Postman, 1952). But there has been no systematic attack on the problem, and wide gaps remain in our knowledge. The purposes of the present experimental program were to investigate certain relationships not considered in the earlier work and to explore further some of the factors previously evaluated. Particular emphasis was laid upon the analysis of the effects of frequency of occurrence upon responses to ambiguous cues.

## EXPERIMENT I

There were two principal goals to this experiment. The first was to investigate the functional relationship between the fre-

quencies with which stimulus figures are experimentally experienced and the frequencies of responses to cues which are parts of two or more of these figures. At one point in the presentation of his model of recognition, Binder (1955) assumed that an "individual uses a frequency of designation of a particular class name equal to $P_i n$ where $P_i$ is the objectively measured probability of occurrence of the given class and $n$ is the number of repetitions of the set of conditions" (p. 123). If we consider the probability of occurrence of an object equal to the relative frequency of its previous occurrence in the given context, this leads to the prediction that the relative frequency of a particular response to ambiguous cues is equal to the relative frequency of occurrence of that response and its associated stimulus. The second goal was to test the hypothesis that *S*s who learn to discriminate among objects on the basis of configurations of cues learn to make accurate classifying responses on the basis of parts of these configurations. As stated above, this is an implicit assumption in the models of Binder (1955) and of Bruner (1957).

## *Method*

*Subjects.* The *S*s were all volunteers from various sections of introductory psychology at Indiana University. The learning task was very difficult, and only *S*s who were prepared to spend up to two hours in the experiment were used. The data of about one-fourth of the participating *S*s had to be eliminated because of administrative errors, the failure of some to reach the first criterion level by about 90 min., and the necessity for some to leave near the 2-hr. mark. The average time needed for completion of the experiment was about 85 min. All *S*s were run individually, but grouped according to procedure. The data of 35 *S*s in Group I-E and 31 in Group I-U were usable.

*Apparatus.* The *S*s sat about 5 ft. from the exposure apparatus which consisted of a plywood panel with two separated 8 in. high by 8¼ in. wide one-way vision mirrors located in approximately the center of the panel. Attached to the plywood panel, on the experimenter's (*E*'s) side, was a box with an open front face and grooved sides to hold the stimulus and response cards. The cards were illuminated by four (for each mirror) six-watt bulbs which were placed behind the mirror so as to provide relatively even illumination of the surfaces of the cards and yet not be visible to the *S*s from their normal viewing position. Panel, table, and box were all painted a dull black.

The apparatus was situated in a semidarkened room, and *S*s could see the stimulus and response cards only when the bulbs behind the mirrors were on. At other times, of course, they could only see the reflecting surfaces of the mirrors. The mirrors were designed to provide 33% transmission of light, 33% reflection, and absorption of the remaining light.

*Presentation materials.* Eight nonsense syllables of 33% association value were used as names during the learning trials of the experiment (Glaze, 1928). The names are as follows: TUZ, RUX, WOY, JOM, KAL, NAF, VED, and GEP. Eight stimulus figures were also used and may be seen in Fig. 1. The squares within which the differentiating cues are placed are 4 in. in length on each side. These stimulus figures were designed in such a way that every cue within the common square was necessary for some discrimination.

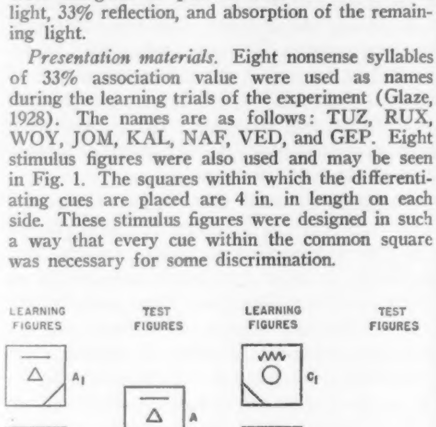


FIG. 1. Learning figures and test stimuli for Exps. I, II, and III.

The three test stimuli may also be seen in Fig. 1. Test Stimulus A contains the set of cues common to Figures $A_1$ and $A_2$, Stimulus B the set of cues common to $B_1$ and $B_2$, and Stimulus C the cue common to $C_1$, $C_2$, $C_3$, and $C_4$.

All stimuli and names were drawn on white drawing board. Great care was taken during the drafting to ensure that each cue common to four stimulus figures, such as the circle or the straight line at the upper part of the square, appeared in the same location of the exposure surface when the respective figures were placed in the grooves on the box. Similarly, the cues appearing on the test cards were placed so as to provide for alignment on the viewing surface of common cues on learning and test figures.

*Procedure.* All *S*s were trained by the method of paired associates (with correction) during the learning phase, with stimulus figures appearing in

the left mirror and nonsense syllables in the right mirror. The following intervals were used: stimulus exposure 5½ secs., response exposure 2 secs., intertrial interval 7½ secs., and delay after warning buzzer 1½ secs. The delay between blocks averaged about 30 secs., but was never less than 22 secs.

The procedures used for the *S*s in Group I-E and those in Group I-U differed only in the composition of each learning trial block. For the *S*s in Group I-E, a trial block consisted of a single presentation of each of the eight stimulus figures together with its associated nonsense name. The trial blocks for the *S*s in Group I-U contained figure-name pairs presented varying numbers of times. In the trial blocks of Group I-U, either $A_1$ or $A_2$ occurred twice and the other once, $B_1$ or $B_2$ occurred four times and the other once, and one of $C_1$, $C_2$, $C_3$, or $C_4$ occurred three times and the other three once each. While $A_1$ and $A_2$ always appeared in the ratio of two to one per trial block, the particular one which occurred twice and the one which occurred once were randomly determined for different *S*s. In a similar fashion, whether $B_1$ or $B_2$ appeared four times per block and whether $C_1$, $C_2$, $C_3$, or $C_4$ appeared three times per block were randomly determined. Table 1 shows a summary comparison of the trial blocks for the two groups. This table can be considered only representative, of course, since the particular one of a subset (like $A_1$ or $A_2$) which occurred more frequently varied randomly over *S*s. The Group I-U trial blocks in all cases consisted of 14 pairings.

The nonsense syllables paired with particular figures were randomly determined for different *S*s. The *S*s were instructed that the associated nonsense syllables were to be considered the names of the figures and that they were to anticipate each figure's name after the figure was exposed but before its nonsense name appeared. To make this more like a recognition situation, the *S*s pronounced rather than spelled out the nonsense syllables. During the first trial block, *E* pronounced each syllable as it appeared, in order to minimize any reluctance on the part of *S*s to pronounce any syllable.

TABLE 1

NUMBER OF OCCURRENCES OF LEARNING FIGURES PER TRIAL BLOCK FOR ONE POSSIBLE ASSIGNMENT IN EXP. I

| Learning Figure | Group I–E | Group I–U |
|---|---|---|
| $A_1$ | 1 | 2 |
| $A_2$ | 1 | 1 |
| $B_1$ | 1 | 4 |
| $B_2$ | 1 | 1 |
| $C_1$ | 1 | 3 |
| $C_2$ | 1 | 1 |
| $C_3$ | 1 | 1 |
| $C_4$ | 1 | 1 |
| Total Presentations per Block | 8 | 14 |

The ordering for the presentation of stimuli for each odd-numbered trial block was determined by a randomization schedule which *E* had prepared in advance. A restriction imposed on the randomized order was that a single stimulus could not appear more than twice in succession. The reverse order of presentation to that of the immediately preceding odd-numbered block was used for each even-numbered block. The sequence of randomized order as read from the schedule, reversal of that order, new randomized order, etc. was repeated with only one break until a criterion of two consecutive blocks of perfect anticipations was reached. This break consisted of a 5-min. rest period at the end of 40 min. (if the criterion had not been reached by this time). At the criterion point of two perfect blocks, the *S*s were given another 5-min. rest period. After this rest period, the presentation of learning blocks of paired associates was repeated until the *S*s achieved one more block of perfect anticipations. They were then given their first test trial, and this was followed by the learning trials necessary for another block of perfect anticipations. Then came the second test trial, learning trials to one further block of perfect anticipations, and finally the last test trial. The purpose of the learning blocks intervening between all test trials was to assure as far as possible that the *S*s maintained the learning level achieved previously.

The three test trials which all *S*s were given consisted of single presentations of each of the Stimuli A, B, and C (see Fig. 1). The order of presentation of these three stimuli was randomized with the one restriction that Stimulus C was not to appear on the first trial. The test stimuli were shown for a duration of 1¼ secs., beginning 1½ secs. after the sounding of the warning buzzer. The intertrial interval was 9 secs. For the test phase of the experiment only the left mirror of the exposure apparatus was used.

Immediately following the first criterion of two consecutive perfectly anticipated trial blocks, the *S*s were told that they were ready for the second phase of the experiment in which a new figure would be presented after each further block of all correct responses. They were told that the new figure would not be exactly like any of those shown before and would be exposed for a shorter period of time, but that they were to respond with the name of the most closely related figure. The additional instructions during the actual test phase, after the 5-min. break, were as follows:

> In order to make sure that you still remember the characteristics together with the correct name of each of the figures presented during the first part of the experiment, I will now present them in the same way once again. As before,

I would like you to name the figure shown in the left window just as soon as you can after it is exposed, before the name is shown a few seconds later in the right window. We will not go on to the new figure, which I told you about before, until you complete a run giving the correct name of all of the figures before their names are shown in the right window. Correct any misses or mistakes as you did previously.

[After criterion of one perfect block]:

Now here is a new figure. Give the one name out of the set you have learned which seems most appropriate, even though this figure is not exactly like any of those just shown. No name will appear in the right window. (The figure became visible to the *S*s about 9 secs. after the completion of these instructions.)

[After exposure of first test stimulus]:

Once again we will rerun the figures and names as in the first part of the experiment to make sure you remember them. Name the figure before its name appears in the right window and correct misses and errors.

After the criterion of one further errorless block was achieved, the same instructions were read as after the perfect block above ("Now here is a new figure," etc.). These were repeated once again before the final test trial. The instructions which followed the first test stimulus ("Once again we will rerun," etc.) were reread prior to the final set of trials of paired associates.

## *Results and Discussion*

Let us consider an example in terms of the responses to Test Stimulus A (see Fig. 1) in order to illustrate how the results may be analyzed. If an *S*'s response to A is the name of either Figure $A_1$ or Figure $A_2$, it is called an appropriate response. If he responds with one of the names of any of the other six figures, it is called an inappropriate response. A third category of response could occur if an *S* did not follow instructions and responded to a test stimulus with a name which had not occurred during learning. This happened in very few cases, and these responses were placed in the inappropriate category. Thus, we can consider the results in terms of the number of appropriate responses to A as opposed to the number of inappropriate responses, and in terms of the relative number of $A_1$ and $A_2$ naming responses to A. Similar analyses may be made of the responses to Test Stimuli B and C.

The numbers of appropriate and inappropriate responses as well as the numbers of responses of differing learning frequency within the appropriate category may be seen in Tables 2 and 3. The frequencies expected from the hypothesis that relative frequency of response equals relative frequency of learning occurrence are shown parenthetically in the columns designated "Appropriate Responses." The correspondence between the values expected on the basis of this hypothesis and those actually obtained is obviously close. However, it will be most convenient to delay a fuller discussion of these particular results until the data are analyzed in terms of the appropriate–inappropriate dichotomy.

According to the second hypothesis stated in the introduction to Exp. I, *S*s who had learned the figure–nonsense name associations perfectly might have been expected to have made no inappropriate test responses. But, despite the fact that a strin-

TABLE 2

OBTAINED AND EXPECTED (IN PARENTHESES) RESPONSE FREQUENCIES TO TEST STIMULI FOR *S*s IN GROUP I–E

| Test Stimulus A | | | | |
|---|---|---|---|---|
| Appropriate Responses | | | | Inappropriate Responses |
| $A_1$ | $A_2$ | | | |
| 15 | 15 | | | 5 |
| (15.0) | (15.0) | | | |
| **Test Stimulus B** | | | | |
| Appropriate Responses | | | | Inappropriate Responses |
| $B_1$ | $B_2$ | | | |
| 15 | 13 | | | 7 |
| (14.0) | (14.0) | | | |
| **Test Stimulus C** | | | | |
| Appropriate Responses | | | | Inappropriate Responses |
| $C_1$ | $C_2$ | $C_3$ | $C_4$ | |
| 8 | 7 | 7 | 11 | 2 |
| (8.25) | (8.25) | (8.25) | (8.25) | |

TABLE 3

OBTAINED AND EXPECTED (IN PARENTHESES) RESPONSE FREQUENCIES TO TEST STIMULI FOR *S*s IN GROUP I–U

| Appropriate Responses | | Inappropriate Responses |
|---|---|---|
| **Test Stimulus A** | | |
| A(2) | A(1) | 8 |
| 20 | 3 | |
| (15.3) | (7.7) | |
| **Test Stimulus B** | | |
| B(4) | B(1) | 5 |
| 20 | 6 | |
| (20.8) | (5.2) | |
| **Test Stimulus C** | | |
| C(3) | All C(1) Pooled | 3 |
| 13 | 15 | |
| (14.0) | (14.0) | |

gent criterion was used, *S*s made errors in terms of misclassification up to the final one of the required five perfect blocks. A factor based on incorrect anticipations during the learning trials following the achievement of the first three required perfect trial blocks was accordingly used to estimate the imperfection in learning at criterion.

In order to make a correct anticipation during learning, a given *S* must use all the information in the form of cues: circle or triangle, wavy or straight line at the top, and line at right or left corner (see Fig. 1). He must, in other words, classify correctly according to three dichotomies. An incorrect response may result from an error in one, two, or three of those dichotomous categorizations. If the figure exposed happens to be $B_2$, for example, a response consisting of the name of $B_1$ or $A_2$ would result from one misclassification while the name of $C_4$ to $B_2$ would represent three misclassifications.

The computations used in arriving at the expected number of appropriate and inappropriate test responses on the basis of the errors in anticipation made by *S*s at criterion are outlined in Table 4. For all *S*s, total number of misclassifications on all trials, following the first three required perfect trial blocks, were counted. Also counted were the total number of blocks, over all *S*s in the respective groups, after the third perfect one and up to and including the fifth perfect one. Since each block for Group I-E contained eight trial pairings and three classifications were necessary per trial (one for each cue), the total number of necessary categorizations for the *S*s in Group I-E after the third perfect block is the total number of trial blocks multiplied by 24 ($8 \times 3$). The multiplier in the case of the *S*s in Group I-U is 42 ($14 \times 3$) since there were 14 trials per block for Group I-U. The number of misclassifications per attempted categorization at criterion for each group was obtained by dividing total misclassifications by the number of necessary categorizations.

The number of inappropriate responses expected purely on the basis that the *S*s had not learned to classify without error using each of the three cues could now be computed. When presented with Test Stimuli A or B (see Fig. 1) each *S* had to categorize on the basis of two cues, while when presented with C he had to make only one dichotomous categorization (one of the $C_i$ [$i = 1, 2, 3, 4$] stimulus figures or not a $C_i$ stimulus figure). The total number of categorizations necessary by the *S*s in Group I-E to Stimulus A was 70 ($35 \times 2$); to B, 70; and to C, 35. The comparable numbers for the *S*s in Group I-U were 62, 62, and 31. The total number of necessary test

TABLE 4

PERFORMANCE IN LEARNING TRIALS FOLLOWING FIRST THREE REQUIRED PERFECT BLOCKS IN EXP. I (Summed Over All *S*s)

| | Group I–E | Group I–U |
|---|---|---|
| Total Misclassifications | 91 | 83 |
| Trial Blocks | 128 | 113 |
| Necessary Categorizations | 3072 | 4746 |
| Misclassifications per Attempted Categorization | .0296 | .0175 |

TABLE 5

FREQUENCIES OF APPROPRIATE AND INAPPROPRIATE RESPONSES TO TEST STIMULI FOR BOTH GROUPS OF *S*s IN EXP. I

| Group | Test Stimulus | Obtained Responses | | Expected Responses | |
|---|---|---|---|---|---|
| | | Appropriate | Inappropriate | Appropriate | Inappropriate |
| I–E | A | 30 | 5 | 33 | 2 |
| I–E | B | 28 | 7 | 33 | 2 |
| I–E | C | 33 | 2 | 34 | 1 |
| I–U | A | 23 | 8 | 30 | 1 |
| I–U | B | 26 | 5 | 30 | 1 |
| I–U | C | 28 | 3 | 30 | 1 |

categorizations multiplied by the number of misclassifications per categorization at criterion gives the total expected inappropriate responses to the test stimuli.[2]

The expected frequencies of appropriate and inappropriate responses and also the obtained frequencies may be seen in Table 5. Fisher's exact test was applied to all differences between expected (on the basis of actual learning responses) and obtained frequencies, and only the difference due to the responses of the *S*s in Group I-U to Test Stimulus A is significant. The significance level is $P \leq .05$. It would seem reasonable to conclude that these results support the hypothesis that *S*s can identify components of the stimuli to which they previously learned names.

Perhaps a final remark should be made on the justification for choosing the learning trial blocks following the third required perfect block for predicting frequencies of inappropriate test responses. Each *S* had to achieve five blocks with perfect anticipations: two consecutive ones during the learning phase, one more after a 5-min. rest period, and one additional perfect block after each of the succeeding two test trials. It was necessary to be sure that *S*s were at criterion level of performance for these computations of misclassifications and the trial blocks prior to the first two perfect ones could obviously not be used. Nor could the trials between the second and third perfect blocks be used since a rest period, and presumably some forgetting, had intervened between these blocks. After the third perfect block, however, only a 1¼-sec. test trial and a very brief set of instructions came between successive learning trial blocks. This made it reasonable to assume that the *S*s were not below their first criterion level during this period.

For the sake of facilitating future discussion (with specific reference to the *S*s in Group I-U) it is convenient to introduce notation to allow us to refer to the stimulus figure occurring at a given frequency per block, regardless of the specific figure it may be. Accordingly, let A(1) be the $A_i$ ($i = 1$ or 2) figure which occurs once per block for a certain *S* (as randomly determined) and A(2) the $A_i$ figure occurring twice per block for the *S*. Thus if $A_1$ occurs twice per block and $A_2$ once as a result of the random determination, A(1) refers to $A_2$ and A(2) to $A_1$ in this particular case. In a similar fashion, let B(1) be the $B_i$ ($i = 1$ or 2) occurring once per block, B(4) the $B_i$ occurring four times per block, C(1) any of the three $C_j$ ($j =$ 1 or 2 or 3 or 4) figures occurring once per block, and C(3) the $C_j$ figure occurring three times per block for a given *S*.

Let us return to the comparative frequencies which were obtained within the category of appropriate response. Table 2 contains the frequencies of the responses of the *S*s in Group I-E to the three test stimuli. The numbers in parentheses were obtained for a given test stimulus by the formula

$$\frac{O_i}{O_s}(N)$$

where $O_i$ represents the number of times

[2] This requires the assumption that each *S* who gives an inappropriate response makes only one misclassification in doing so. But this would seem entirely reasonable since the average number of misclassifications for each erroneous anticipation during learning was 1.09 for the *S*s in Group I and 1.02 for those in Group II. And to make the argument even stronger, the maximum number of misclassifications possible was three during the learning trials and only two during the testing trials.

the $i^{th}$ figure occurred on each learning trial block, $O_s$ represents the number of times the learning figures containing all cues of the given test stimulus occurred per trial block, and $N$ represents the total number of appropriate responses given to the test stimulus by all *S*s. As an example of the use of this formula, consider the responses to Test Stimulus A (Table 2). In this case the total number of appropriate responses, or $N$, is 30. If the learning figure of interest (that is, the $i^{th}$ figure) were $A_2$, $O_i = 1$. Since there are two learning figures containing all cues of Test Stimulus A (that is, $A_1$ and $A_2$) and they occurred a total of twice per trial block, $O_s = 2$. Therefore, we have

$$\frac{O_i}{O_s}(N) = \tfrac{1}{2}(30) = 15$$

We thus predict a total of 15 responses to Test Stimulus A consisting of the name previously associated with $A_2$. The parenthetical numbers in Table 2 are in all cases, then, the frequencies of various appropriate responses which would be expected if the *S*s were giving particular appropriate responses at the same relative frequencies as the occurrence of their associated stimuli per learning trial block.

Table 3 contains the comparable obtained and expected frequencies for *S*s in Group I-U. The numbers in parentheses for a given test stimulus are not equal (as in Table 2) since the learning stimuli were presented at differing frequencies per trial block.

The relative frequencies expected on the basis of learning occurrences were considered theoretical (population) values in testing for the significance of the difference between obtained and expected relative frequencies. The binomial test was used for the five cases in which the appropriate responses fell in two classes, and the $\chi^2$ test for the one case involving four appropriate classes of response (that is, the responses to Stimulus C for the *S*s in Group I-E). Only one of these six comparisons showed a significant difference ($P \leq .05$). This again occurred in the responses to Stimulus A for the *S*s in Group I-U.

Since much of the above is consistent with recency, it was desirable to check upon whether or not the particular appropriate responses given tended to be the last encountered in learning. Accordingly, the learning block preceding each test trial for the *S*s in Group I-E was examined to see if the test response was or was not the most recent of the possible appropriate responses. It should be emphasized that, for this purpose, only appropriate test responses to a given test stimulus were considered and the sequence of figure–name pairs during the immediately preceding learning block was evaluated only from the standpoint of the ordering of appropriate responses. Thus the two appropriate responses to A are the names of $A_1$ and $A_2$ and, when either of these names was given, the prior learning block was examined to see if the stimulus–response pair corresponding to that name did or did not occur after the other possible pair which could have been named. The test responses to B and C were similarly analyzed. Since there are only two appropriate responses to Stimuli A and B, chance occurrence with no recency effect would be indicated by an equal division of the appropriate responses into "last" and "not last" categories. In the case of Stimulus C there are four appropriate responses, so one in four can be expected to be a last response by chance. Table 6 contains the number of appropriate responses to each of the three test stimuli which were and which were not the names of learning figures oc-

TABLE 6

NUMBER OF APPROPRIATE RESPONSES FOR GROUP I–E WHICH WERE AND WERE NOT LAST LEARNING RESPONSE (AS COMPARED WITH OTHER POSSIBLE APPROPRIATE RESPONSES)

| Test Stimulus | Last | | Not Last | |
|---|---|---|---|---|
| | Obtained | Expected by Chance | Obtained | Expected by Chance |
| A | 12 | 15 | 18 | 15 |
| B | 14 | 14 | 14 | 14 |
| C | 10 | 8.25 | 23 | 24.75 |

curring last (ignoring inappropriate stimulus names) in the immediately preceding learning block. Table 6 also gives chance expectations for "last" and "not last" responses. Adding up all "last" and "not last" responses gives sums of 36 and 55, respectively. When one considers that purely random responding with regard to "lastness" gives expectations of 37.25 "last" occurrences and 53.75 "not last" occurrences, it is clear that the data present no evidence for a recency effect large enough to effect the above interpretations. However, it should be pointed out that this test is surely not sensitive enough to detect the small sequence effects predicted and found by such investigators as Estes and Straughan (1954).

As a final recency comparison, it was found that 16 of the total of 105 responses (appropriate and inappropriate) given by all *S*s to all test stimuli were the names of the very last stimulus (considering all eight learning figures in this case) to occur in the previous learning blocks. This compares with an expectation of 13.1 if the *S*s were giving the most recent of all learning responses purely on a chance basis.

Thus, a very striking relationship between the perceptual variable, frequency of response to an ambiguous testing stimulus, and the learning variable, frequency of occurrence of figures in blocks of paired associates, was found. The evidence supports the preliminary prediction that the frequencies of responses consisting of the various possible appropriate figure names parallel the frequencies with which the *S*s had previously responded to the figures.

In only one of the comparisons did this relationship fail to hold: that was in the case of the responses of the *S*s in Group I-U to Test Stimulus A. There were other idiosyncrasies in this particular case. First, as pointed out above, this was the only group that gave significantly more inappropriate responses than expected on the basis of misclassifications during learning trials at criterion. And second, if one looks at the particular kinds of inappropriate responses made, one finds that six of the eight errors consisted of the name of Figure $C_4$ to Test Stimulus A (see Fig. 1). Notice that $C_4$ differs from the appropriate response to A, $A_1$, only in that the former has a wavy line and the latter a straight line at the top. In all other test trials the inappropriate responses were much more evenly scattered over the possible choices. The five inappropriate responses of the *S*s in Group I-E to Test Stimulus A, for example, consisted of one $C_2$ name, one $B_1$ name, one $B_2$ name, and two $C_4$ names.

While it is hardly startling, support was also found for the hypothesis that *S*s who have learned differentiating responses to configurations of cues are able to make accurate discriminatory classifications on the basis of cue components. As mentioned above, the only discrepancy in six comparisons was the generally pathological case of the responses to Stimulus A by the *S*s in Group I-U.

## Experiment II

The primary purpose of this experiment was to test further the hypothesis that the relative frequency of an appropriate recognition response to ambiguous cues is equal to the relative frequency of that response and its associated stimulus during previously reinforced learning trials. A secondary purpose was to explore the generality of this relationship by altering the conditions in the one previous experimental situation in which it did not hold. This alteration was accomplished by dividing the eight stimulus figures of Fig. 1 into two sets and then administering them to separate groups of *S*s. The division of figures was such that the appropriate response figures for the test stimulus giving the discrepancy in the previous experiment (that is, A) were in one part and the figure associated with the inappropriate response which seemed to be the source of difficulty (that is, $C_4$) was in the other. This division had the further very marked advantage of reducing the average time necessary to complete the experiment from the approximately 85 min. required of the *S*s in Exp. I to about 25 min. This facilitated the accumulation of much larger sample sizes, which seemed very desirable

in attempting to verify the relationships found previously.

## *Method*

*Subjects.* The *S*s were volunteers from the introductory psychology course at Indiana University. All *S*s were run individually but were considered to be in one of two groups in accord with the learning procedure used. Group II-AB contained 55 *S*s; and Group II-C, 54 *S*s. In contrast to the losses of Exp. I, very few *S*s were lost because of administrative difficulties in this experiment.

*Apparatus and materials.* The same apparatus, stimulus materials, and response words as in Exp. I were used.

*Procedure.* All *S*s were trained by the method of paired associates in the manner described for Exp. I, with only those changes necessitated by the different stimulus groupings. The stimuli used for the *S*s in Group II-AB were $A_1$, $A_2$, $B_1$ and $B_2$ during the learning trials and A and B during the test trials. The name associated with a given figure was randomly determined for each *S* from among the eight possibilities.

Each trial block for *S*s in Group II-AB was eight stimulus–response presentations in length; two of the four figures occurred more than once per block. The specific figures replicated varied randomly over *S*s. For some *S*s, Figure $A_1$ and its associated nonsense syllable occurred twice per block and Figure $A_2$ once, while for others $A_1$ occurred once and $A_2$ twice. Similarly, Figure $B_1$ occurred four times per block and $B_2$ once for some *S*s, while $B_1$ occurred once and $B_2$ four times for others. Once chosen for a given *S*, the assigned frequencies for the figures were maintained through all of his learning blocks. The following is an example of stimulus composition and ordering for a Group II-AB block: $B_1$, $A_2$, $B_2$, $B_2$, $A_1$, $B_2$, $A_2$, $B_2$.

The stimuli used for the *S*s in Group II-C were $C_1$, $C_2$, $C_3$, and $C_4$ during the learning trials and C during the test trial. Again four of the syllables were randomly matched with the learning figures for different *S*s. The learning trial blocks for the *S*s in Group II-C were only six figure–name pairings in length. One among $C_1$, $C_2$, $C_3$, and $C_4$ was exposed three times per trial block and the other three once each, but the more frequently occurring one was chosen randomly for different *S*s. Once chosen, this remained the figure which occurred three times through all the trial blocks for an *S*. A possible figure composition and ordering for a block of Group C is $C_4$, $C_1$, $C_4$, $C_4$, $C_3$, $C_2$.

Prior to the learning trials, the *S*s in both groups were told that the nonsense syllables were to be considered the names of the figures and that their task in subsequent trials was to anticipate this name after the figure was exposed but before the name appeared. The order of presentation within a block during learning was random on odd-numbered trial blocks (with the restriction of no more than two consecutive appearances) and the reverse of the previous odd-numbered block on even blocks. Learning proceeded to a criterion of two consecutive trial blocks with perfect anticipation. After reaching this criterion, all *S*s in both groups were given a 5-min. rest period, at the end of which the paired-associates blocks were repeated until they achieved one further block of perfect anticipations.

The Group II-AB *S*s were then given their first test trial, and this was followed by a further set of learning blocks to a criterion of one more perfect block. Then came the final test trial. During the two test trials of the *S*s in Group II-AB, Test Stimulus A was presented once and Test Stimulus B once in random order over *S*s (see Fig. 1).

Following the rest period and succeeding trials to one perfect block, the *S*s in Group C were given a single test trial consisting of Test Stimulus C. This terminated the experiment for them.

Prior to each test trial all *S*s were told that a new figure, somewhat different from all those used during learning, would be presented and that they were to respond with the one previously learned name which seemed most appropriate. They were informed of the criterion requirements in terms of necessary perfect trial blocks preceding all learning stages.

## *Results and Discussion*

Table 7 contains the number of *S*s in Group II-AB who gave appropriate and inappropriate responses to Test Stimuli A and B. It also contains the number of *S*s who gave the various appropriate responses to Stimulus C in Group II-C. To illustrate the table's meaning, when presented with Test Stimulus A, 36 of the 55 *S*s in Group II-AB gave an appropriate response consisting of the name of the learning figure which occurred twice as frequently as the other in their learning blocks, that is, A(2); 16 *S*s made A(1) and three *S*s made inappropriate responses (B's or C's). The numbers in parentheses in Table 7 are the response frequencies we would expect if the *S*s responded with appropriate responses at the same relative frequencies as their occurrence in the learning trial blocks; they were obtained as described in Exp. I.

The very few inappropriate responses obtained makes it reasonable to account for the phenomenon of inappropriate responding solely on the basis of imperfect learning of name pairs. This confirms the previous finding.

TABLE 7

OBTAINED AND EXPECTED (IN PARENTHESES) RESPONSE FREQUENCIES TO TEST STIMULI FOR ALL *S*s IN EXP. II

| Test Stimulus A (Group II–AB *S*s) | | |
|---|---|---|
| Appropriate Responses | | Inappropriate Responses |
| A(2) | A(1) | $B_1$ or $B_2$ |
| 36 | 16 | 3 |
| (34.7) | (17.3) | |
| **Test Stimulus B (Group II–AB *S*s)** | | |
| Appropriate Responses | | Inappropriate Responses |
| B(4) | B(1) | $A_1$ or $A_2$ |
| 42 | 11 | 2 |
| (42.4) | (10.6) | |
| **Test Stimulus C (Group II–C *S*s)** | | |
| C(3) | All C(1) Pooled | |
| 37 | 17 | |
| (27.0) | (27.0) | |

The fit between obtained and expected frequencies for the responses of the *S*s in Group II-AB to Test Stimulus A, on the one hand, and Stimulus B, on the other, is remarkably close. Statistically, the small differences between obtained and expected values are very far indeed from approaching significance. These data surely lend support to the hypothesis that the relative frequencies of various recognition responses to ambiguous cues equal the relative frequencies with which these responses occurred previously in association with their stimuli.

However, using a $\chi^2$ test, the difference between the obtained and expected responses to Test Stimulus C by the *S*s in Group II-C is significant at the .05 level. In looking at these data in Table 7, it should be remembered that the expectation of equal frequencies in the two appropriate response categories stems from the fact that, although one learning figure among the $C_j$ occurred three times as frequently per learning block as each of the other three—that is, C(3)—all responses consisting of the names of the three less frequent learning figures—all C(1)—have been pooled. In effect this means that one expects as many responses consisting of the more frequent name as all three less frequent names combined.

These results are of particular significance when compared with the findings of Exp. I. In Exp. II, the *S*s in Group II-AB, who were tested on A after learning trials involving the same ratio of presentation of $A_1$ and $A_2$ as the *S*s in Group I-U (that is, 2 to 1), never saw the $C_j$ learning figures. Consequently, the source of difficulty involving a large number of inappropriate $C_4$ responses to A was eliminated. The present data, therefore, support the hypothesis that the large number of inappropriate responses (of a particular kind) contributed toward producing the single significant discrepancy between relative frequencies during learning and relative frequencies among appropriate test responses in Exp. I.

The present data from *S*s in Group II-C are at variance with the previous finding of no significant difference between expected and observed frequencies for the same test stimulus and the same learning presentation frequencies. In fact, the obtained and expected values for Group I-U are almost identical. How can we account for this marked difference in results? Assuming that the difference was not due simply to chance sampling fluctuations, we must look at the essential difference between the two experiments and consider its possible effects. The *S*s of Group I-U were trained on all eight learning figures and tested on all three test stimuli, while the *S*s in group II-C were trained on only the four $C_j$ learning figures and tested on C. The entire set of learning and test stimuli of the present experiment was only part of a larger set in the earlier experiment. In other ways—relative frequency of presentation among learning figures, learning criterion requirements prior to testing, nonsense syllables potentially paired with learning figures, over-all method of learning and test presentation, and instructions—the two experiments were identical.

In the case of the *S*s in Group II-AB as well as in the case of the *S*s in Group I-U, the trial blocks for all *S*s contained at least

two stimuli which appeared more than once. This was not the case with the *S*s in Group II-C who had only one stimulus presented more than once per block. When in repeated blocks of four different stimuli, one stimulus appears three times and the others appear only once each in successive blocks of six trials, it seems reasonable to assume that the more frequent stimulus becomes relatively conspicuous. Thus, 49% of the *S*s made no errors in identifying the C(3) stimulus throughout their learning trial blocks (excluding the first block, of course, during which *E* read aloud the names). Moreover, 59% made no errors in identifying C(3) during either the second, third, or fourth blocks; and 66% made no errors in identifying it during the second block alone. Fig. 2 contains separate curves of total errors per attempted anticipation to the C(3) figure, on the one hand, and to all three C(1) figures, on the other. Errors and attempted anticipations were summed over all *S*s for each block. Zero errors were assumed for *S*s who had reached the criterion of two perfect blocks prior to a given block. It is apparent that most *S*s learned the name of C(3) within the first two blocks and spent the remainder of their learning time in discriminating among the C(1)s.

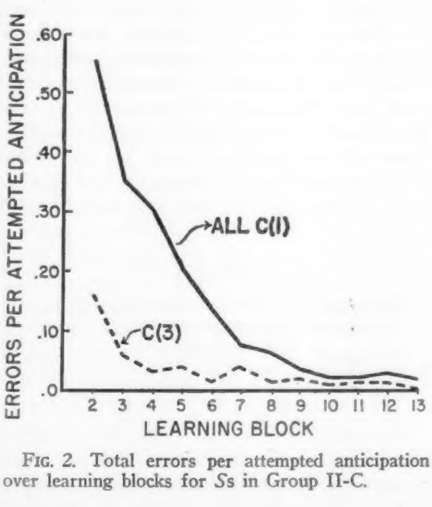


FIG. 2. Total errors per attempted anticipation over learning blocks for *S*s in Group II-C.

This would imply that for many *S*s there was more immediacy and fewer cue-producing responses involved in the association between the C(3) stimulus and its naming response, at least at certain stages of learning. Let us use an example to illustrate this argument. Suppose the paired associates for a given *S* in Group II-C are as follows: $C_1$—WOY, $C_2$—RUX, $C_3$—KAL, and $C_4$—GEP (see Fig. 1). Suppose, further, that $C_3$ occurs three times per block for this *S*, and $C_1$, $C_2$, and $C_4$ once each. Now this *S* quickly learns to respond "KAL" when $C_3$ is exposed. If this association is not immediate and such intermediate implicit responses as, "triangle, wiggly line, line to left" occur, they quickly drop out with the overlearning concomitant with the frequent repetition of only one stimulus. The essential body of learning consists of establishing discriminations among $C_1$, $C_2$, $C_4$. But this may require a good deal of emphasis and drilling on cue-producing responses. Thus, the learning may involve drilling on sequences like: $C_1$ exposed—"circle in middle and line in left corner"—"WOY"; or $C_4$ exposed—"triangle in center and bottom line to right"—"GEP." If this process of discriminating among the C(1) with the help of implicit responses proceeded through the learning trials for these *S*s, the difference in immediacy between responses to these stimuli and the response of "KAL" to $C_3$ would, up to a point, become more and more pronounced. When the Test Stimulus C is presented after that course of learning, a certain *S* might respond in some such fashion as: "No circle in the middle and no line in left corner, it is not a WOY; no line in right corner, it is not a RUX; no line in right corner and no triangle in center, not a GEP." The elements to which the cue-producing responses leading to the responses of "WOY," "RUX," and "GEP" are, in short, not present. The *S* then gives the response "KAL," the name of the stimulus which appeared three times per block.

With enough *S*s of Group II-C behaving in accord with the above model, the disproportionately large number of C(3) names becomes understandable. Unfortunately there was no way of evaluating the

reasonableness of these formulations with the data thus far available and so new data had to be collected with proper experimental variation.

## Experiment III

The purpose of this experiment was to test the hypothesis that the discrepancy between obtained and expected response frequencies for the *S*s in Group II-C resulted from the unusual distinctiveness of the particular figure occurring three times as often as the others per learning block. According to the analysis, this distinctiveness resulted in the *S*s learning the more frequent figure–name association comparatively directly and the less frequent figure–name associations with the aid of intervening implicit responses. And this in turn, presumably, led to a larger than expected frequency of the associated name of the C(3) figure on tests with Stimulus C.

The method used in this experiment involved a replication of the conditions used for the *S*s of Group II-C with one change introduced to reduce the distinctiveness of the figure which occurred three times per block. This diminution in distinctiveness was accomplished by increasing the frequency per block of two of the other three figures.

### *Method*

*Subjects.* Sixty-five *S*s were used in this experiment. As in the previous experiments they were run individually and all were volunteers from introductory psychology sections.

*Procedure.* The apparatus and stimulus and response materials were the same as those described previously. Except for the specific composition of each learning trial block, the procedure used for the *S*s in Exp. III was identical to that used for the *S*s of Group II-C. Whereas each block for the *S*s of Group II-C consisted of one $C_j$ presented three times and the other three once each, the blocks in the present experiment consisted of one $C_j$ presented three times, another presented once, and the remaining two figures presented twice each. The learning blocks for the *S*s of Exp. III were, consequently, eight pairings in length. The particular figures among $C_1$, $C_2$, $C_3$, $C_4$ presented once, twice, and three times per block were chosen randomly for a given *S*, but once selected the particular figure frequencies were of course maintained through all of his learning blocks.

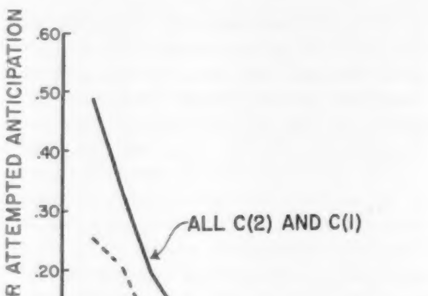


Fig. 3. Total errors per attempted anticipation over learning blocks for *S*s in Exp. III.

### *Results and Discussion*

The condition whereby two learning figures occurred twice each per learning block surely would be expected to diminish the distinctiveness of the figure which occurred three times. That this occurred is indicated by the fact that 34% of the *S*s made no C(3) errors throughout their learning trial blocks; 37% made no C(3) errors on blocks two, three, or four; and 54% made none on block two alone. (The corresponding percentages for the *S*s in Group II-C are 49, 59, and 66.) Fig. 3 shows (for the *S*s in Exp. III) curves of errors per attempted anticipation to the C(3) figure, on the one hand, and the pooled C(2) and C(1) figures, on the other hand. Ordinate values were determined as in Fig. 2.

Let us evaluate the effects of this diminished distinctiveness. Table 8 contains the

TABLE 8

Obtained and Expected (in Parentheses) Response Frequencies to Test Stimulus for *S*s in Exp. III

| C(3) | Both C(2) | C(1) |
|---|---|---|
| 25 (24.4) | 31 (32.5) | 9 (8.1) |

obtained and expected response frequencies of the *S*s in Exp. III to Test Stimulus C. Responses consisting of the name of either of the two C(2) figures were necessarily pooled since, considering that the figures presented at each frequency were random for a given *S*, there was no way of distinguishing between them in a frequency analysis over *S*s. The expected frequencies were computed by the procedure described above.

The closeness of the fit between expected values and obtained results is remarkable indeed. This supports the hypothesis that the discrepancy between obtained and expected values for the *S*s in Group II-C resulted from the unusual distinctiveness concomitant with the single figure's comparatively large number of occurrences per block. This does not, of course, provide powerful confirmation to the steps of the argument wherein the unusual distinctiveness is assumed to lead to the differential use of cue-producing responses and these in turn to a preponderance of test responses consisting of more frequent figure names. But there would seem to be no more compelling line of reasoning available to account for the discrepancy. Moreover, the presented line of reasoning was heuristic, and any other would be ex post facto.

The accuracy of prediction for these data make it seem desirable to determine if the obtained results are consistent with the independence of expected outcomes and the effects of recency. Table 9 contains this analysis. A given entry for predicted proportion is simply the product of the probability that the particular figure will occur last (or not last) during the final learning block and the probability, assuming the matching relationship holds, that the name of the figure will be given on the test trial. For example, the probability that C(3) is the last figure exposed is .375 and the probability that it will be named according to the matching hypothesis is .375; hence, the predicted proportion of C(3) responses when it is last is (.375)(.375) = .141. Again, the fit between predicted and obtained values is very close, indicating both the accuracy of prediction from the matching hypothesis as well as the relative unimportance of recency effects.

TABLE 9

OBTAINED AND EXPECTED PROPORTIONS OF RESPONSES IN RECENCY COMPARISON FOR EXP. III

| | Test Stimuli | | | | | |
|---|---|---|---|---|---|---|
| | C(3) | | Both C(2) | | C(1) | |
| | Last | Not-Last | Last | Not-Last | Last | Not-Last |
| Obtained | .139 | .246 | .092 | .385 | .046 | .092 |
| Predicted | .141 | .234 | .125 | .375 | .016 | .109 |

Thus, the results of Exp. II and Exp. III taken jointly provide very convincing support for the earlier finding of a direct relationship between a learning variable and a perceptual variable. Moreover, these results provide a relatively clearly defined set of conditions under which the relationship breaks down.

## EXPERIMENT IV

The purpose of the present experiment was to provide one test of the hypothesis that, in a recognition situation, discriminative and common cues differ in the extent to which they are effective in determining responses because of differential sampling. Such differential sampling or, in other terms, selective attention has been hypothesized by certain theorists to account for perfect, or near perfect, discriminations in situations involving overlapping cues and common background stimulation.

In their application of statistical learning theory to the analysis of discrimination learning, for example, Estes and Burke (1955) found evidence for a reduction of common elements in the stimulus situation over the course of learning. La Berge and Smith (1957) explicitly pointed out that the assumptions of statistical learning theory imply that an individual making perfect

discriminations in two-choice learning should be selectively ignoring common elements. They found support for the hypothesis that background common cues are ignored, in an experiment involving changes in partial reinforcement schedules with interspersed test trials consisting of only background elements.

Wyckoff (1952) used the term "observing responses" to designate those responses of an *S* which are necessary for exposure to the discriminative stimuli. Wyckoff presented an analysis of changes in the probabilities of these responses in terms of reinforcement learning theory, equating these changes with alterations in stimulus generalization between the stimuli. Atkinson (1959) dealt with observing responses within the framework of a Markov model, in an approach related to the earlier work of Wyckoff. He modified the typical discrimination task significantly by equating observing responses with the operation of selection keys, in order to make the process of selective attention directly measurable. Restle (1955), on the other hand, used Lawrence's (1950) concept of "irrelevant cues," which are those aspects of a stimulating situation which are unrelated to reinforcement. Restle hypothesized that these irrelevant cues become progressively adapted over the course of learning, and thus eventually cease to influence the discrimination responses of *S*s. Recently, Restle (1957) has presented a more general theory of discrimination learning in which rate of adaptation is a function of the information-giving value ("validity") of the available cues. Finally, Green (1958) described the process of selective sampling of stimulus elements in terms of a reduction of the intercept or common set as a result of postural or orientation adjustments.

In summary, these investigators have attempted to account, by means of such concepts as "observing responses" and "cue adaptation," for the process whereby *S*s learn to ignore the common (or nondiscriminative or irrelevant) cues in discriminating among stimuli. The term "selective sampling" will be used to designate this process throughout the present discussion since the expressions "observing responses," "cue adaptation," and "cue neutralization" carry connotations which are not intended. "Selective sampling" will imply no more than a designation of conditions, at a given discrimination point, whereby certain cues are effective in influencing responses while others are not.

In order to test the hypothesis that selective sampling occurs in recognition situations of the sort investigated in the preceding experiments of this project, use was made of the finding that the relative frequencies of responses to ambiguous cues tend to equal the relative frequencies of occurrence of these responses in previous S–R associations. Current research would indicate that selective sampling occurred in the preceding experiments, since the majority of *S*s learned to discriminate among the figures during the learning trials with no errors after the initial criterion of two perfect blocks was reached. The postulate in statistical learning theory (Estes & Burke, 1955), for example, that the probability of a response on a given trial is equal to the proportion of conditioned elements leads to the assumption that the common elements in both the figures and the background were not sampled (that is, were ignored) in the process of response determination.

Paired-associates learning was again used in this experiment in the manner of the previous experiments. The present experiment differed from the others, however, in that the relative frequencies of presentation of the learning stimuli per trial block were changed once during the course of learning. The purpose of the shift was to introduce a different rate of conditioning of the stimulus elements. For those *S*s for whom selective sampling had been operative at the time of the shift, the ignored cues would not be conditioned at the new rate. A determination of whether common cues were responded to at the initial relative frequency or at the relative frequency following the shift then provided a means of assessing if selective sampling had actually occurred.

### *Method*

*Apparatus.* The exposure of stimuli and responses was accomplished by the apparatus described in Exp. I.

*Subjects.* Two groups of 38 *S*s each were used in the experiment. They were volunteers from the introductory psychology sections at Indiana University.

*Materials and procedure.* Four learning figures and three test stimuli were used; these may be seen in Fig. 4. A paired-associates procedure was used during the learning phase, in which the figures shown in the left hand column of Fig. 4 were

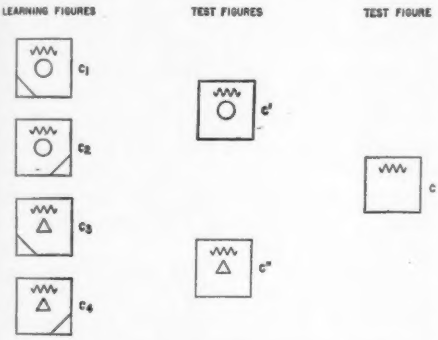


FIG. 4. Learning and test figures for Exp. IV.

associated with the nonsense syllables RUX, TUZ, WOY, JOM. The matching of figures and syllables was done randomly over *S*s. The sound of a buzzer preceded each stimulus presentation.

The timing of presentations and intertrial intervals was the same as that of Exp. I.

For the first three trial blocks, each stimulus response pair was shown once per block. Then, assuming that a set of three learning blocks is a reasonable interval in which to expect selective sampling to begin occurring, a differential frequency of presentation per block was used beginning with the fourth block and continuing through the learning phase. During these latter blocks, $C_3$ or $C_4$ occurred twice and the other once, while $C_1$ or $C_2$ appeared four times and the other once. While $C_3$ and $C_4$ always appeared in the ratio of two to one per trial block, the particular one which occurred twice and the one which occurred once were randomly determined. In a similar fashion, whether $C_1$ or $C_2$ appeared four times per block was randomly determined for different *S*s. The order of presentation was random on odd blocks and the reverse of the previous odd block on even blocks.

Upon achieving two trial blocks with perfect anticipations, the *S*s were given a 3-min. rest period. Then, during the test phase of the experiment, they were required to achieve one further perfect trial block before each test trial. The test trials consisted of the presentation of C, $C'$, and $C''$ (see Fig. 4) to all *S*s. Test Stimulus $C'$ contains a cue set common only to Figures $C_1$ and $C_2$, Stimulus $C''$ a cue set common only to $C_3$ and $C_4$, but Stimulus C contains nothing but cues common to all four learning figures.

The two experimental groups differed in the ordering of the test trials. The Group IV-$C'$ *S*s were tested on either Stimulus $C'$ or Stimulus $C''$ first, the remaining one of these two stimuli second, and Test Stimulus C last. The Group IV-C *S*s were shown C first, and then $C'$ and $C''$ randomly ordered, second and third.

For the learning instructions, the *S*s in both groups were told that the nonsense syllables were to be considered the names of the figures and that the syllables were to be pronounced in the process of anticipation. Prior to each test trial all *S*s were told that a new figure would be presented and that their task was to respond with the one previously learned name which seemed most appropriate.

It became apparent after these *S*s were run that a control group was needed. This was needed because no previous data were available for *S*s tested on a stimulus like C after a 2:1:4:1 frequency throughout learning (that is, starting with 2:1:4:1 during the first block and maintaining that frequency on all subsequent blocks). Accordingly, a group of 29 *S*s was run with $C_1$ and $C_2$ shown in a 4:1 ratio and $C_3$ and $C_4$ in a 2:1 ratio throughout learning (see Fig. 4). The test stimulus consisted of C alone.

### *Results and Discussion*

If an *S* gives an appropriate response to Test Stimulus $C'$ (that is, the name of $C_1$ or $C_2$), his subsequent response to $C''$ must be different (that is, the name of $C_3$ or $C_4$) or else it will be inappropriate. And the same holds, of course, for the sequence $C''$ and then $C'$. In that sense, the responses to $C'$ and $C''$ are necessarily independent for any analysis involving specific appropriate responses. In contrast, the same responses are appropriate to either $C'$ or $C''$, on the one hand, and C, on the other. Thus, it is possible to have sequential dependencies in terms of recurrences of the same response which is appropriate for both stimuli. The previous experiments avoided the problem of possible lack of independence by using only those test stimuli (like $C'$ and $C''$) in the group administered to a given *S*, for which the associated sets of appropriate responses were nonoverlapping.

The present investigation was so designed that the effects of using successive test stimuli for which the same responses were appropriate could be determined with little loss of experimental time. All *S*s were shown the three stimuli C, C′, and C″ in such a fashion that C came either first or last. Thus, if it were found that the response patterning to the C′ and C″, on the one hand, and C, on the other, are independent, the combined data could be used; but if no such independence were shown, the data for the *S*s seeing C first and those seeing it last could be analyzed separately, which would have been necessary even if all test stimuli had not been shown to each *S* as in the present investigation of independence.

Table 10 contains the response frequencies to the test stimuli for the Group IV-C′ and Group IV-C *S*s. The response patterning would seem to be quite different for the two groups, with a distinct tendency for lower frequency responses to occur to C when C′ or C″ came first and to C′ and C″ when C came first. Thus, the ratio of more frequent to less frequent responses is 2:1 for C″ and 2.5:1 for C′ in the case of the Group IV-C′ *S*s, and the corresponding ratios are 1.5:1 and 1.7:1 for the Group IV-C *S*s. These data may be compared with those for Group II-AB because of the similarity of learning frequencies and test conditions in the two situations. The ratio of more frequent to less frequent responses for the *S*s in Group II-AB is 2.2:1 to Test Stimulus A (comparable to C″) and 3.8:1 to Test Stimulus B (comparable to C′). This comparison adds some weight to the evidence of nonindependence in test responses when the same response is appropriate to successive test stimuli, despite the marked discrepancy in response tendencies between C′ and B. It is surely clear that the response ratios to C′ and C″ are much closer to the results for the *S*s in Group II-AB when C′ and C″ appear prior to C than when they appear after C.

In the case of the responses to Test Stimulus C, there is an increase, when C comes last, in the responses which occur at frequencies of two and one at the expense of those of frequency four (see Table 10). The results from the group of 29 control *S*s are relevant here. These were: 16 responses associated previously with the figure occurring four times, 7 responses which occurred twice, and a total of 6 of the two responses which occurred once each. These data are much more nearly like the results when C was presented first than when it was presented last.

All the data from this experiment, as compared with the results for Group II-AB and for the control group of 29 *S*s, indicate that the learning blocks of Exp. IV subsequent to the third were not completely effective in overcoming the response tendencies stemming from the three initial blocks of equal frequency. That is, when the four learning figures are presented equally frequently for three blocks and then shifted to a 2:1:4:1 frequency, there is an increase in the relative frequencies during testing of naming responses of figures which occurred only once per learning block, as compared with the results when no shift occurs and the frequency 2:1:4:1 is main-

TABLE 10

RESPONSE FREQUENCIES (FOR EXP. IV) IN TERMS OF THE LEARNING FREQUENCIES OF ASSOCIATED STIMULI

| Group | Number of *S*s | First Test Stimulus | C″ 2 | C″ 1 | C″ Error | C′ 4 | C′ 1 | C′ Error | C 4 | C 1 | C 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IV–C′ | 38 | C′ or C″ | 22 | 11 | 5 | 27 | 11 | 0 | 9 | 17 | 12 |
| IV–C | 38 | C | 19 | 13 | 6 | 22 | 13 | 3 | 17 | 13 | 8 |

Note.—Numbers in columns headed by C″, C′, and C refer to frequency of occurrence, during learning, of named figure, if appropriate.

tained throughout learning. Moreover, as pointed out above, there is a further increase in the frequency of test responses consisting of the names of figures which occurred once per block when the test stimulus followed (for a given *S*) other test stimuli having the same appropriate responses. This latter increase may have resulted from the attempts of *S*s to use as many different testing responses as possible. That is, there were obviously more high than low frequency responses initially and so any general tendency toward using different responses on subsequent test trials would lead to a net shift in the direction of low frequency responses.

In any event, as a result of the indicated lack of independence, only the C′ and C″ test responses of Group IV-C′ and the C responses of Group IV-C were used in the analysis of selective sampling.

Table 11 contains the distribution of errors made subsequent to the first required criterion level of two blocks with perfect anticipations. It should be remembered that all *S*s were required to achieve one further perfect block before each test trial. The deviation from perfect responding during criterion trials may conceivably have resulted from inadequate selective sampling of discriminative cues. Consequently, each of the two groups was divided into two parts: one part contained those *S*s who made no errors whatsoever in the learning blocks following the first two required perfect ones, and the other part contained *S*s who made one or more errors during these blocks. For ease of designation, Group IV-C′-NE shall refer to those *S*s who were shown Stimulus C last and made no errors during the criterion blocks, Group IV-C′-E, to those *S*s who were shown Stimulus C last and made one or more errors during the criterion blocks; and Group IV-C-NE and Group IV-C-E shall have similar meanings.

The curves, over all learning blocks, of average number of errors per *S* in each of the four subgroups may be seen in Fig. 5. There is some difference in learning trend evident between the Group IV-C′-NE and Group IV-C′-E *S*s, on the one hand, and the Group IV-C-NE and Group IV-C-E *S*s, on the other. It is hardly surprising that the "NE" *S*s as a group were more efficient learners than the "E" *S*s. There would seem to be little difference between the learning rates of the *S*s in Group IV-C′-NE and those in Group IV-C-NE during the later blocks, and these will be the critical comparison groups in the analyses of selective sampling. The average number of blocks to reach the final necessary perfect criterion block for each of the subgroups is as follows: Group IV-C′-NE, 11.24; Group IV-C′-E, 12.61; Group IV-C-NE, 10.58; Group IV-C-E, 12.95. The difference between the Group IV-C′-NE and Group IV-C-NE *S*s is small and far from significant.

We would expect, if selective sampling occurs, that it does so for the *S*s at high

TABLE 11

TOTAL ERRORS OF ANTICIPATION MADE BY *S*s IN EXP. IV IN LEARNING BLOCKS FOLLOWING FIRST PERFECT CONSECUTIVE PAIR

| Errors | Number of *S*s |
|---|---|
| 0 | 44 |
| 1 | 15 |
| 2 | 12 |
| 3 | 2 |
| 4 | 1 |
| 5 | 1 |
| 6 | 1 |

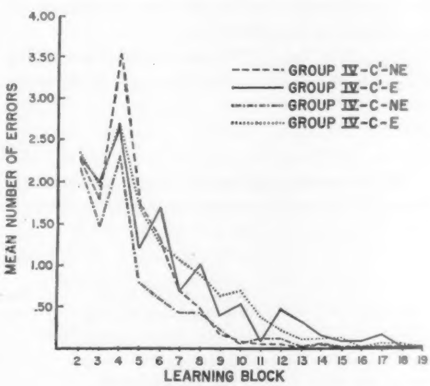


FIG. 5. Mean number of errors per *S* for the four groups in Exp. IV.

learning levels who show perfect discriminations over the criterion blocks.

Table 12 contains a summary of the test responses of the various subgroups in terms of the frequencies of occurrence of the associated learning figures. Responses consisting of the name of a figure which occurred twice or four times per block have been pooled under the "More Frequent" heading, while those consisting of a name occurring once per block have been pooled under "Less Frequent." All erroneous test responses were eliminated from consideration. The pooling into these two categories was done because of the relatively small frequencies which would have resulted from the finer breakdown involving the actual numbers of learning occurrences.

Expected frequencies for the pooled data can be computed by the usual rules for combining fractions. Thus, for example, the "More Frequent" responses should occur three times as often as the "Less Frequent" responses if the *S*s in Group IV-C-NE responded to the test stimuli at the same relative frequencies as the occurrence of the relevant figure–name pairs during later learning. If selective sampling had occurred prior to the fourth block, however, an equal number of C responses in the "More Frequent" and "Less Frequent" categories would be predicted. That is, if the common cues were not sampled as a result of selective attention, they could not be conditioned to the various responses at the differing frequencies.

Stimuli C′ and C″ contain discriminative cues which could not be ignored if *S*s were to give correct anticipations during learning. Hence, approximately a 2.82 to 1 ratio of "More Frequent" to "Less Frequent" responses was expected for the *S*s in Group IV-C′; the expectation is approximate rather than exact because of the previously noted ineffectiveness of the shift to 2:1:4:1 in completely overcoming the response tendencies stemming from the first three blocks of equal freqency. The test for the hypothesis of selective sampling involved the Group IV-C-NE *S*s, since they responded to the test stimulus containing only common cues and showed perfect discriminations at criterion trials. Table 13 shows observed and expected values for the *S*s in Group IV-C′-NE and also for the *S*s in Group IV-C-NE.

The observed and expected values do not differ significantly for the Group IV-C′-NE *S*s ($P > .25$) using a $\chi^2$ test. The observed values for the Group IV-C-NE *S*s differ significantly from that expected if they did not selectively sample ($P \leqq .05$), but do not differ significantly from the values expected under the assumption of selective sampling by the fourth block ($P = 1.00$).

It is interesting to note further (see Tables 12 and 13) that the *S*s in Group IV-C-E responded very close to the 3:1 learning ratio (14.25 to 4.75 expected vs. 15 to 4 observed). It is surely clear that the Group IV-C-E *S*s did not show selective attention. It is conceivable that their comparative learning inefficiency resulted from their deficiency of selective sampling among common and discriminative cues. Noting the response ratios of the Group

TABLE 12

RESPONSE FREQUENCIES IN TERMS OF LEARNING FREQUENCIES OF ASSOCIATED STIMULI FOR EXP. IV

| Group | Performance After First Criterion Blocks | Number of *S*s | Test Stimuli | Learning Occurrence of Stimulus–Response Pair: More Frequent | Less Frequent |
|---|---|---|---|---|---|
| IV–C′–NE | No errors | 25 | C′ and C″ | 33 | 14 |
| IV–C′–E | One or more errors | 13 | C′ and C″ | 16 | 8 |
| IV–C–NE | No errors | 19 | C | 10 | 9 |
| IV–C–E | One or more errors | 19 | C | 15 | 4 |

TABLE 13

OBSERVED AND EXPECTED RESPONSE FREQUENCIES FOR *S*s OF EXP. IV

| Group | Value Source | | Learning Occurrence of Stimulus–Response Pair: More Frequent | Less Frequent |
|---|---|---|---|---|
| IV–C′–NE | Observed | | 33 | 14 |
| | Expected | (Differential Frequency Matching) | 34.67 | 12.33 |
| | Observed | | 10 | 9 |
| IV–C–NE | Expected | (Selective Sampling) | 9.5 | 9.5 |
| | Expected | (Differential Frequency Matching) | 14.25 | 4.75 |

IV-C-E and the Group IV-C′-NE *S*s in Table 12 (3.75 : 1 and 2.36 : 1, respectively), the relatively low number of "More Frequent" responses on the part of the IV-C′-E *S*s becomes difficult to account for on any basis other than sampling fluctuation. If the data for the *S*s in Groups IV-C′-E and IV-C-E are combined, they give a total of 31 "More Frequent" and 12 "Less Frequent" responses. This is very much like the response ratio for the Group IV-C′-NE *S*s.

To summarize, this experiment provided a test of the hypothesis that responses to ambiguous cues are a function of differential attention to discriminative as compared to common stimulus elements during the process of learning the names of relevant stimulus figures. The test was based on the usual presumption that learning only occurs with cues actually sampled. This being the case, it was assumed possible to detect cessation in the sampling of certain cues by an initial learning experience followed by an altered learning experience subsequent to the assumed cessation. If selective sampling occurred to the given cues, test responses to them at the end of the learning period should have been in accord with the initial learning; while, if selective sampling had not occurred, the responses should have been in accord with altered learning.

Only *S*s at high criterion levels of learning were used since it appeared likely that lower levels of learning may have resulted from poor selective attention. It was found that *S*s who were shown discriminative cues responded in accord with the later (altered) learning experience, while *S*s shown only common cues responded in accord with the initial learning experience. This supported the hypothesis of selective sampling in perceptual-type situations involving common and discriminative cues.

The data are in accord, moreover, with the findings of La Berge and Smith (1957) that a change in the partial reinforcement schedule associated with the common cues shown on test trials produces no change in the level of response for *S*s near asymptote but does produce a change for *S*s further from asymptote. While the theory of Restle (1955, 1957) on the adaptation of common cues accounts for the general findings, it does not contain a sufficiently clear formulation of the relationship of adaptation to conditioning. Thus, the *S*s in the present experiment responded quite accurately to the common cues which had presumably been previously adapted. Restle, to be sure, recognizes the phenomenon in his recent statement (1959) that "irrelevant cues are 'neutralized' relative to the relevant cues present, and recover if the relevant cues are removed or scrambled" (p. 14) as well as in his previous comment (1958) that, when certain cues are removed, invalid cues recover and performance tends to change. But it is not apparent just where these observations fit into his more formal theory of discriminative learning.

It would seem more economical at the present time to consider the sampling and conditioning processes separately in accord with the formulations of Estes and Burke (1953). In this way a given stimulus element may be conditioned to a response but be ineffective in eliciting the response be-

cause it is not sampled. The probability of sampling the given element may be thought of as going to zero during the process of selective attention. When the stimulus situation is changed sufficiently so that the element is again sampled, its previous conditioning is still effective.

## Experiment V

In all of the experiments reported so far the $S$s learned to associate nonsense names with nonsense figures which contained overlapping cues. Following the learning, the $S$s were required to name a test stimulus which contained only cues which were common to two or more of the previous learning figures. There was, in the terms used in the introduction, ambiguity as a result of reduction of information when the full set of cues was necessary for unique discrimination. Moreover, the test situation and analysis were devoid of phenomenological or "autistic" considerations. Surely it would not be easy to argue that an $S$ who called a given test stimulus a RUX "really saw" the figure with which that name had been associated. Such phenomenological constructs could be anchored by other aspects of the behavior of the $S$ as well as by appropriate questioning. These aspects of perception will be discussed more fully later.

Nevertheless, these considerations led to Exp. V. The test stimuli of Exp. V differ from those of Figs. 1 and 4 in that their ambiguity results from too many, rather than too few, cues; and in addition, there is probably more of a "really see" reaction associated with responses to them. Perhaps these should not be listed as two factors because of their close interdependence, but it is convenient to do so to highlight the separate aspects.

The learning and test stimuli used in this experiment were based on those employed by Schafer and Murphy (1943). These experimenters hoped to demonstrate that perception was influenced by "needs." They attempted to show that, when $S$s were required to name an ambiguous presentation consisting of a combination of a previously rewarded and previously punished profile, the latter would form the ground while the former would stand out as figure. The stimuli used by Schafer and Murphy were identical to those in Fig. 6 except that each of their learning figures also included the eye dot of the profile that would be its compliment when it was presented as part of a test figure.

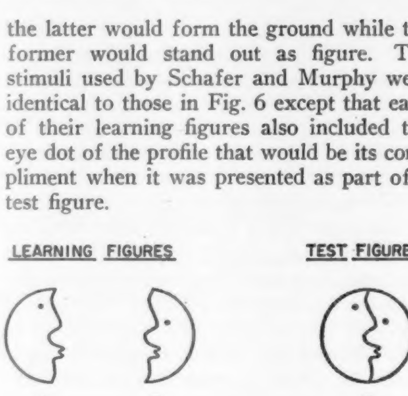


Fig. 6. Learning and test figures for Exp. V.

In the Schafer and Murphy experiment $S$s were shown the four half-moon faces and were required to learn their names. For each $S$ one face in each pair (such as $F_1$ or $F_2$) was regularly rewarded (2 or 4 cents given to $S$) while the other face was regularly punished (2 or 4 cents taken from $S$). The test stimuli of Fig. 6 which contain the combination of both figures of a pair, one rewarded and one punished, were then shown to the $S$s under instructions to name them. Fifty-four rewarded as opposed to 13 punished names were given to the test stimuli.

Rock and Fleck (1950) repeated the Schafer and Murphy study but failed to confirm the previous findings. However, as pointed out by Jackson (1954), there were several changes in the Rock and Fleck procedure that may have accounted for the differences in results. Among the changes were: younger $S$s, the use of symbols rather than proper names, the change in "reward value" of 2 and 4 cents since 1943, and the use of a projection tachistoscope which resulted in larger faces, lessened clarity, and

the absence of a constantly lighted field. Jackson repeated the Schafer and Murphy study with some modifications, including increased rewards, and once again showed that rewards and punishments had their predicted effects. However, when he substituted a projector, for presentation purposes, with a second group of *S*s, his findings concurred with those of Rock and Fleck.

Smith and Hochberg (1954), substituting 15-in. solid figures for the outline profiles, demonstrated that a shock vs. no shock condition resulted in findings similar to those obtained for monetary reward and punishment. *S*s gave a significantly larger number of nonshocked figure names when they were required to name ambiguous test figures.

More recently, Solley and Sommer (1957) replicated the Schafer and Murphy experiment using children, increased monetary rewards, and solid profiles. They obtained a significantly greater number of rewarded names when their *S*s were shown the ambiguous test presentations for one-min. periods and were asked to describe what they saw. In a second experiment, these authors found that *S*s reported the rewarded profiles as "happier," "brighter," "closer," and as having a dark line drawn around them. Solley and Sommer concluded that reward "produced a genuine figure-ground reorganization" (p. 9).

Considering these results the purpose of this experiment may now be stated: (*a*) to test predictions of the relationship between relative frequency of S–R association and relative frequency of naming identification and (*b*) to compare the effects of frequency upon responses with those of rewards and punishments. In addition, because of certain modifications introduced in the present experiment, some information about the generality of previous findings might be established.

### *Method*

*Subjects.* The *S*s were 66 volunteers from the courses in introductory psychology at Indiana University. The learning criteria were not met by two of these *S*s and, therefore, the data from 64 *S*s were included in the analyses.

*Apparatus.* The apparatus employed was essentially the same as that described in Exp. I. The only important difference was in the size of the exposure mirrors, which were 3 in. by 3 in. in the present experiment.

*Learning and test materials.* Each *S* was required to learn the nonsense names of four half-moon faces. The four faces used for any *S* were either direct photographic reproductions of those faces employed by Schafer and Murphy with the eye dot exception as noted previously (see Fig. 6) or photographic reproductions of the negative images of these faces. This pool of eight figures was such that figures could be paired on the basis of shared common contours. The test figures consisted of these paired figures. Thus, if $F_1$, $F_2$, $G_1$, and $G_2$ were shown during the learning phase, the pairings $F_1$ and $F_2$ to produce F and $G_1$ and $G_2$ to produce G were the two test figures.

The test figures were 2½-in. photographic reproductions mounted on cardboard which, upon presentation, were seen centered in the appropriate window. A given face, whether it appeared individually or as part of a test figure, never varied from a set location of exposure. The nonsense syllables were printed in ½-in. india ink capitals, on cardboard, such that on presentation they were seen as centered in their window. The four nonsense syllables used were WOY, JOM, RUX, and TUZ.

*Procedure.* The procedure was similar to the one used in the previous experiments. However, the following intervals were used: exposure of stimulus 4 sec., exposure of response 2 secs., interval between trials 6 secs., and delay after warning buzzer 1 sec.

Eight trials constituted a learning block. On any block, one member of a pair containing common contours appeared four times while the other member appeared once. The ratio of the frequencies of presentation of the members of the other pair was two to one. An example of the relative frequencies of presentation of the four faces for a given *S* may be seen in Table 14.

TABLE 14

NUMBER OF OCCURRENCES OF LEARNING FIGURES PER TRIAL BLOCK FOR ONE POSSIBLE ASSIGNMENT IN EXP. V

| Learning Figure | Frequency |
|---|---|
| $F_1$ | 4 |
| $F_2$ | 1 |
| $G_1$ | 2 |
| $G_2$ | 1 |

The order of presentation of the trials for each block was random. An attempt was made to control for possible biases for particular faces and directions by the use of a counterbalanced design, such that for a given *S* the particular group of pairs used, the pair that was shown in the four to one ratio, and the member of higher frequency within each pair were randomly determined.

The learning procedure continued until an *S* anticipated perfectly on two consecutive trial blocks. After a rest period of 3 min., the *S* was told that following the next perfect block he would be shown a new figure and would be required to give one of the names of the previously learned figures. Following this perfect block the *S* was reminded of his task and then shown a test stimulus. The test stimuli were shown for a duration of 1½ secs., beginning 1 sec. after the sounding of the warning buzzer. After the first test response, the *S* was required to anticipate perfectly another block and was then shown the second test figure. The order of presentation of the test figures was random, with the restriction that the figures corresponding to the 4:1 and 2:1 pairs were shown first an equal number of times.

### *Results and Discussion*

Table 15 shows the observed and predicted frequencies of responses to the test stimuli. The column headed by "Four" contains the number of obtained and predicted responses designating the name of a face that appeared four times per learning block. The other columns correspondingly contain the number of responses designating figures which were shown at the frequencies shown in the column heading. The errors are inappropriate responses. Referring to Fig. 6, if the Test Figure G were shown, a response consisting of the name of $F_1$ or $F_2$ would be inappropriate. If the components of the Test Figure G had been presented in a four to one ratio, an error made to this figure would be represented in the third column, and if the ratio were two to one, in the last column.

The predicted frequencies refer to the number of appropriate responses expected on the basis of the hypothesis that the relative frequencies of appropriate responses to ambiguous cues are equal to the relative frequencies of presentation of the names associated with these cues during the learning phase.

The differences between expected and observed values (at least for the 4:1 comparison) are quite large, especially as compared with the very close fits obtained in the previous experiments. Using a $\chi^2$ test, the observed and predicted frequencies differ at the .01 level in the 4:1 comparison and at the .20 level in the 2:1 comparison. The hypothesis of the matching of relative frequencies of responses and relative frequencies of occurrence during learning trials in this type of situation is certainly not well-supported by these data.

There are a number of differences between the present experimental conditions and the earlier ones in this project. First, the specific learning figures differ; second, the present figures are more meaningful than those used previously; third, the ambiguity in the test stimuli resulted from an increase of cues in the present case, while it resulted from an impoverishment of cues in the previous experiments; and fourth, while certain cues in the previous experiments were on a partial reinforcement schedule, all cues in the present experiment received 100% reinforcement. There is one other difference which, though less obvious than any of the preceding, seems of utmost importance. The configurations of cues in

TABLE 15

OBSERVED AND EXPECTED RESPONSES TO THE TEST STIMULI IN EXP. V

| Learning Figures | Appropriate Responses: Four | Appropriate Responses: One | Inappropriate Responses | Appropriate Responses: Two | Appropriate Responses: One | Inappropriate Responses |
|---|---|---|---|---|---|---|
| Observed | 40 | 21 | 3 | 32 | 23 | 9 |
| Predicted | 48.8 | 12.2 | | 36.7 | 18.3 | |

TABLE 16

NUMBER OF *S*s[a] SWITCHING AND REPEATING RESPONSES ON THE TWO TESTINGS IN EXP. V

| | | Second Response Frequency | | | | | Second Response Frequency | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Four | One | Row Sum | | | Two | One | Row Sum |
| First Response Frequency | Two | 9 | 8 | 17 | First Response Frequency | Four | 13 | 8 | 21 |
| | One | 6 | 2 | 8 | | One | 2 | 5 | 7 |
| | Column Sum | 15 | 10 | | | Column Sum | 15 | 13 | |

[a] Only *S*s who gave two appropriate responses are included in analysis.

the stimuli of the present experiment were such that the second test stimulus was obvious to an *S* once the first test stimulus had been seen. This was not the case in the previous experiments where the learning figures were nonsensical and the test configurations were arbitrary choices among the cues of these figures. Thus, while the first and second responses were independent in the previous work, the ability of an *S* to predict that the second compound face would be shown once the first had been exposed could lead to a lack of such independence.

Table 16 divides the appropriate test responses into categories defined on the basis of first and second responses. Thus, for example, it contains the number of *S*s who gave the names of the learning figures of higher frequency on both trials, among those who were presented on the first test trial with the stimulus whose components occurred in a 4:1 ratio and on the second trial with the stimulus containing 2:1 components (that is, 13). The results for the other combinations are similarly included. The differences between response tendencies on the first and second trials are not statistically significant (using Fisher's exact test). However, the very small sample sizes make it extremely unlikely that a significant difference would be found even if the obtained differences were much more extreme. Nevertheless, there are certain tendencies evident in the table: (*a*) a surprisingly large number of marginal responses of low frequency on the second test trial, (*b*) *S*s who give responses of low frequency on the first test trial to the compound face with components shown 4:1 give more responses of low than of high frequency on the second test trial, (*c*) the relative frequencies on the second test trials tend to vary with the particular first test response given (though not significantly).

A conclusion of nonindependence is consistent with the findings of Schafer and Murphy (1943). They encountered, in a pre-experimental phase, a tendency for *S*s to respond, on repeated testings, with the names of faces pointing in a particular direction. They attempted to counteract this effect by inserting, between each test trial, a configuration with only one acceptable face which pointed in the direction opposite that of the face selected on the previous ambiguous trial. However, they found, despite this attempt at obtaining trial-to-trial independence, that after approximately eight exposures of an ambiguous figure, equal percentages of rewarded and punished faces were given. They accounted for this finding in terms of a "new set" and consequently only considered the responses to the first half of their test presentations.

Pastore (1949) criticized Schafer and Murphy's analytical procedure since he felt that the cut-off point was a *post hoc* choice dictated by the fact that the hypothesis was supported only up to the selected point.

Chein, Lane, Murphy, Proshansky, and Schafer (1951) countered by saying that the choice of the sixteenth trial allowed a wide "margin of safety." They pointed out, further, that the responses after the sixteenth trial were not random, rather "there was clear evidence that *another process* intruded and took over" (p. 134).

Rock and Fleck (1950) referred to "a certain consistency which develops in responding to a situation where there is no check on correctness or incorrectness after each trial" (p. 775). They suggested that "a better, though practically infeasible, procedure would be to give, say, 100 *S*s each one trial with each ambiguous situation in order to avoid the contaminating effect of earlier presentations of ambiguous figures upon subsequent ones" (p. 775).

On the basis of these observations, the first test response of each *S* was considered separately for further analysis. Table 17 contains the observed and predicted responses to the first test stimuli. The deviations of observed results from those predicted are indeed small and very far from being statistically significant. Thus, there is some support for the hypothesis that even in a stimulus situation of the sort used in the present experiment, the relative frequencies of the various first test responses to the ambiguous cues tend to be equal to the relative frequencies of occurrence of these responses to their associated cues during learning. This does not hold for the second test responses, apparently, because of a lack of independence. Since the original predictions were made for both test trials and the reasoning toward lack of independence made a posteriori, these results must be cross-validated.

Considering the two testings separately, there are two types of biases that may have been operating to influence the responses given to the ambiguous figures. The first of these is a preference for giving the names of figures pointing in a particular direction. Jackson (1954) found a left-facing preference for the G figure and substituted a new profile set in his replication of the Schafer and Murphy (1943) experiment. Subsequently, he found no directional preferences. However, when he employed the Rock and Fleck (1950) projection procedure he found a left-facing preference. In the present experiment an analysis of directional preferences revealed a left-facing tendency for Test Figure F and its mirror image F′, and also for Test Figure G and its mirror image G′, although the preference was significant only in the former case ($P \leq .05$).

The second bias that might have been operating is a structural one: the naming of that face of the test figure that is more easily seen as a face, that is, "stands out more." For example, if $F_1$ were more readily seen as a face than $F_2$, its name would be given more often independently of learning presentation frequency and directional considerations (right facing in F, left facing in F′). In the present experiment no such preferences appeared, as none of the test figure presentations produced a significantly greater proportion of names of a particular profile than could be expected by chance ($P > .30$, $P > .20$ for F and F′, and G and G′, respectively).

In summary of the work with figures of the Schafer-Murphy type, a number of investigations have demonstrated that per-

TABLE 17

OBSERVED AND EXPECTED RESPONSES TO FIRST TEST STIMULI IN EXP. V

| Learning Figures | Appropriate Responses | | Inappropriate Responses | Appropriate Responses | | Inappropriate Responses |
|---|---|---|---|---|---|---|
| | Four | One | | Two | One | |
| Observed | 22 | 7 | 3 | 17 | 8 | 7 |
| Predicted | 23.2 | 5.8 | | 16.7 | 8.3 | |

ceptual responses could be predicted by an analysis of the previous learning situation in terms of rewards and punishments. The present analysis, however, not only enables us to predict a significant result in a given direction but also enables us to predict an exact quantitative relationship. And while this prediction held for the first testing responses only in the present case, the procedure of analysis involving the discarding of nonindependent data is the same as that used by Schafer and Murphy (1943) (who also discarded half their test); in fact, this mode of analysis conforms to the suggestions of Rock and Fleck (1950) who believed this scheme would provide the most cogent test of the hypothesis under consideration.

The evidence from these experiments, then, points toward the importance of frequency of S–R pairing during learning in determining responses to ambiguous cues. In fact, it indicates, under quite general conditions, a precise quantitative relationship between the variables learning frequency of figures and response frequency to figure parts. But, as discussed above in the introduction, there are many other factors which apparently influence the choice of a particular response out of a larger group of equally accurate responses to a set of ambiguous cues. Some of these are food deprivation (Sanford, 1936; Sanford, 1937; Levine et al., 1942), monetary reward and punishment (Schafer & Murphy, 1943; Proshansky & Murphy, 1942; Solley & Sommer, 1957), electric shock (Smith & Hochberg, 1954), and pleasant and unpleasant stories (Solley & Sommer, 1957). The remaining experiments in this project were directed toward investigation of a few of these types of differential reinforcement.

## EXPERIMENT VI

Recent studies in operant verbal conditioning have shown that the response of "Good" on the part of the experimenter is effective in producing a significant increase in selected response categories. Thus, for example, Taffel (1955) found that the response "Good" was an effective reinforcer in leading to a significant increase in the use of the particular pronouns with which it was associated. And Binder, McConnell, and Sjoholm (1957) found that "Good" was reinforcing in that it led to an increasing usage of "hostile" rather than "neutral" verbs in sentences. (For a thorough review of the literature on verbal conditioning see Krasner, 1958.) The conditioning effect in these studies was found even though the tasks were not presented as learning ones and the *S*s were unaware of both the reinforcement contingency and the actual learning process. In the present series of experiments, interest was of course not centered in acquisition during the learning phase but rather in the choice among responses to reduced cues subsequent to the achievement of criterion. The question was whether or not the experimenter's response of "Good" would produce a test bias in favor of the figure–name pair with which it was previously associated, much as it led to a bias toward a particular class of responses during the acquisition in verbal conditioning.

### *Method*

*Subjects.* Twenty-nine *S*s from the introductory psychology sections at Indiana University were used.

*Apparatus and materials.* The same apparatus as that discussed in Exps. I, II, and III was used. The stimulus materials may be seen in Fig. 7. The dimensional and other specifications for the stimuli may be found in the *Methods* section of Exp. I. The response syllables associated with the stimuli were JOM, VED, NAF, and RUX.

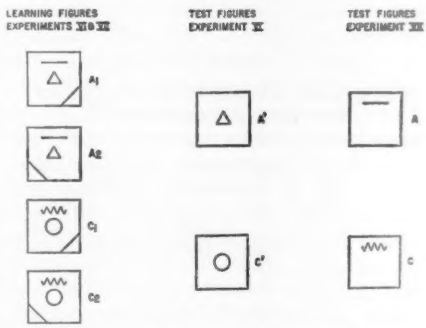


FIG. 7. Learning and test figures for Exps. VI and VII.

*Procedure.* The figures and their associated nonsense syllables were shown to the *S*s by the method of paired associates. Figures and names were paired randomly over *S*s. Except for the experimenter saying "Good" after certain of the *S*s' responses, the learning trials proceeded in the manner of the previous experiments.

A learning block consisted of a single appearance of each stimulus and its response. The experimenter said "Good" immediately after *S* gave the correct response to either $A_1$ or $A_2$, on the one hand, and either $C_1$ or $C_2$ on the other. While the particular stimulus in each pair (that is, $A_1$ or $A_2$ and $C_1$ or $C_2$) associated with "Good" varied randomly over *S*s, all *S*s were reinforced for one member in each of these pairs. The reinforcement was given after the correct responses to the selected stimuli, irrespective of whether *S* had previously learned the correct response or had to read it upon exposure in the right window.

Initial criterion requirements consisted of two trial blocks of perfect anticipations, and then one more perfect block after a 5-min. rest period. The first test trial came next, followed by learning trials to one more perfect block, and then the second test trial. Figures A′ and C′ (see Fig. 7) were shown during the testing, one (selected randomly) on the first test trial and the other on the second test trial. *S*s were instructed to respond with the "most appropriate" name during the testing, but no reinforcement was given regardless of the actual choice.

### *Results and Discussion*

The frequencies of the various responses to the test stimuli are shown in Table 18. The heading "Good" includes names given to the test stimuli which were associated with reinforcement during the preceding learning. The heading Not "Good" has similar meaning. There is obviously no significant difference between the proportions of reinforced and nonreinforced responses within the category of appropriate responses. There is a slight increase in the number of Not "Good" responses relative to the number of "Good" responses from the first to the second test trials. This may be related to the experimental condition whereby no reinforcement was given during the testing. It is interesting to note that in six of the seven cases where an inappropriate response was given it consisted of a reinforced response.

TABLE 18

FREQUENCY OF OBTAINED TEST RESPONSES FOR THE *S*s IN EXPERIMENT VI

| | Appropriate Responses | | Inappropriate Responses | |
|---|---|---|---|---|
| | "Good" | Not "Good" | "Good" | Not "Good" |
| First Test Trial | 12 | 13 | 4 | 0 |
| Second Test Trial | 11 | 15 | 2 | 1 |

The results of this experiment are consistent with the statement (in a footnote) by Jackson (1954), "A third experiment substituting simple verbal 'rewards' (e.g., 'good,' 'that's right') for monetary influences was attempted, but results from six subjects suggested that these were not significantly effective in modifying figure–ground perception" (p. 340).

Although the experimenter's response "Good" apparently had no effect on the choice of names in test responses to the ambiguous cues, the question arises as to whether or not it had any effect during the learning process. That is, was there faster learning of the figure–name pairs associated with "Good" as compared with the figure–name pairs for which the experimenter gave no response? Fig. 8 gives the

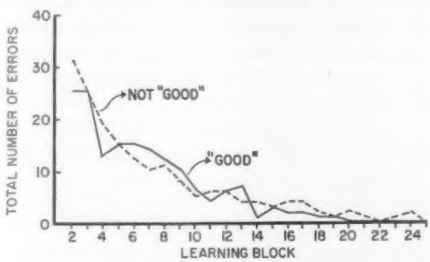


FIG. 8. Total errors over learning blocks for *S*s in Exp. VI.

learning curves of total number of incorrect anticipations per learning block over all *S*s for both "Good" and Not "Good" figures. There is little basis to believe that there is any difference in the efficiency of learning names reinforced by "Good" as compared with names not so reinforced.

Of course, the learning situation under consideration is quite different from the situation in the typical verbal conditioning experiment, where all response classes are immediately evident and learning is measured by an increase in the usage of one of these response classes at the expense of others.

The evidence, then, indicates little effect of the experimenter's response of "Good" upon the determination of responses to ambiguous cues or upon the facility with which responses in paired-associates learning are acquired. Accordingly, in the next experiment attention was focused upon a type of stimulation which seemed more likely to produce a learning effect.

## EXPERIMENT VII

Electric shock was used as punishment in this experiment. The effects of punishment upon the determination of responses to ambiguous cues have been studied by Schafer and Murphy (1943), Proshansky and Murphy (1942), Rock and Fleck (1950), and Jackson (1954). But in these experiments any effects of punishment were completely confounded with those of reward, since one set of cues in every ambiguous configuration was previously always associated with the award of money while the other set of cues in the ambiguous configuration was associated with the withdrawal of money.

Smith and Hochberg (1954) used Schafer and Murphy type figures to investigate the effects of electric shock upon perceptual responses. Each face was exposed for $\frac{1}{3}$ sec. during learning trials, with one face in each reversible pair always associated with electric shock. As in previous studies, 63 presentations of the reversible figures were shown during test trials. There was a significantly greater number of nonshocked than shocked test responses over their entire group of 20 *S*s. Smith and Hochberg concluded that ". . . the 'punishment' (shock) procedure did affect the selection of the figure perceived" (p. 86). They considered their primary problem similar to that of Lazarus and McCleary (1951) who administered electric shock to *S*s in association with certain nonsense syllables. In a series of tachistoscopic test trials, Lazarus and McCleary then found that the average GSR for previously shocked syllables was higher than for nonshocked syllables despite incorrect recognition responses. Smith and Hochberg, contrary to Lazarus and McCleary, found explanations which did not involve "subception" or "perceptual defense" more consistent with their data.

In the Smith and Hochberg experiment, the electric shock accompanied presentation of the shocked face. This is not an entirely satisfactory procedure since the shock may serve as a cue, since it is a part of the total stimulus configuration, and thus function like any other cue during the test trials. Accordingly, in the present experiment the electric shock was presented subsequent to the naming response of the *S*. To be sure, this is contrary to the efforts of Lazarus and McCleary "... to avoid associating the shock with the subject's verbal report and thus influencing his response preference during the final test period" (p. 117). But in the present series of experiments interest was focused upon the responses made in recognition situations and the factors which influence these responses, and not in evaluation of such perceptual constructs as "autism," "subception," and "really see." Specifically, the question to which the experiment was directed was whether or not electric shock leads to a decrease in the tendency to use the response previously associated with a stimulus configuration when the configuration tends to evoke that response as well as others.

In order to assess the effects of differences in the intensity and method of administration of the electric shock, three groups of *S*s were run. For one group, a fixed shock was used for all *S*s; for the second group, the intensity of the shock administered to a given *S* depended on his verbal reports; and, for the third group, an attempt was made to persuade each *S* to take a higher intensity of shock than he would have received if he were in the second group.

### *Method*

*Subjects.* All *S*s were students of introductory psychology at Indiana University. A total of 92 *S*s were run, 21 in Group VII-FS, 29 in Group VII-VS1, and 42 in Group VII-VS2.

*Apparatus and materials.* The apparatus for the controlled exposure of paired associates, as described in Exp. I, was used. The electric shock was administered by a constant current device, calibrated in milliamperes. The maximum possible shock was 10 milliamperes.

The learning figures and test stimuli used in this experiment may be seen in Fig. 7; the nonsense syllables RUX, VED, JOM, and NAF were paired with them. The stimuli lettered A and C in Fig. 7 were shown during the test trials.

*Procedure.* The *S*s in all groups were presented with the figures and nonsense syllables as paired associates during learning. A learning block consisted of the presentation of each figure–name pair once. Electric shock was administered to all *S*s during the learning trials in association with either $A_1$ or $A_2$ and its response, and also in association with either $C_1$ or $C_2$ and its response. The particular member within each of these pairs which was shocked was selected randomly over *S*s.

All *S*s were told that "a very mild electric shock" would be administered and were given a chance to leave if they objected to the shock for either medical or personal reasons. An effort was made to dissuade from leaving those *S*s whose objections seemed based on anxieties very little above the general public's fear of electricity. Nevertheless, about 5% of the total available set of *S*s were lost at this stage.

All *S*s in Group VII-FS were given a shock of six milliamperes. The intensity of the shock for the *S*s in Group VII-VS1 was set at that level which produced the verbal report indicating a pain threshold. Thus, after the electrodes were adjusted on the wrists of the *S*s and before the experiment was started, the following instructions were read:

> I would like to establish the intensity of the electric shock that will be administered during the course of the experiment. As I gradually increase the current intensity through a series of trials, I would like you to tell me the level at which you find the shock "just painful." Before each trial, I will say, "Ready" and then administer the electric shock. Remember, I want you to tell me when the shock is "just painful."

The first level of shock administered was zero milliamperes, the second 2 milliamperes, the third 4 milliamperes, and so on through 6, 7, 8, 9, and 10 milliamperes. The series of increases was stopped either at 10 milliamperes or whenever the *S* reported pain.

An attempt was made to get the *S*s in Group VII-VS2 to accept a current somewhat above the "just painful" level for the *S*s of Group VII-VS1. The preliminary instructions, after the electrodes were fastened, for these *S*s were like those reported above for the *S*s in Group VII-VS1. However, the first shock administered was two milliamperes, and this was increased by two miliampere steps to 10 milliamperes. Additional comments were made during the succession of increases in order to make each *S* a little less self-conscious during the process. Thus, prior to the two milliampere shock, *E* said, "Here is the lowest shock level. Usually people do not feel anything at the first shock intensity. Ready?" And after this shock was administered, *E* asked, "Did you feel anything?" Such comments as, "Now the second level," "Feel anything?" and "How was that?" were made during the subsequent course of intensity determination. When a level of current was reached after which the *S* reported that he could take no more, or that the shock was too painful, or that he wanted to stop, *E* said, "May I try it just a little higher? If it is too high I would be glad to turn it back down." After obtaining permission, the current was increased by one milliampere. Four *S*s refused to try the increase, and only three insisted on the reduction after the increase was made.

Learning proceeded to a criterion of two perfect blocks, a 5-min. rest period, and then another block of perfect anticipations. Two test trials were then given with the trials necessary for one more perfect block coming between them. On the test trials both Stimuli A and C were shown (see Fig. 7), in random order, to all *S*s under instructions to respond with the most appropriate name.

At the conclusion of the experiment all *S*s were asked to state why they gave their particular responses.

### *Results and Discussion*

The mean shock intensities for the *S*s in Groups VII-VS1 and VII-VS2 were 8.2 and 9.1 milliamperes, respectively. The efforts to persuade the *S*s in Group VII-VS2 to accept higher levels of shock were apparently effective.

The response frequencies to the test stimuli in terms of previous association with shock or not-shock may be seen in Table 19. The responses are grouped into "appropriate" and "inappropriate" categories. It is perhaps most useful to consider initially the consistent pattern of alteration over all subject groups from first to second test response. In each case there is a clear shift toward more shocked responses and fewer not-shocked responses. Since no shock was administered during the test trials, it would seem reasonable to assume that this absence is the basis for the altera-

TABLE 19

FREQUENCY OF OBTAINED TEST RESPONSES FOR THE *S*s IN EXP. VII

| | Appropriate Responses | | Inappropriate Responses | |
|---|---|---|---|---|
| | Shocked | Not Shocked | Shocked | Not Shocked |
| Gp. VII–FS | | | | |
| First Test | 9 | 10 | 1 | 1 |
| Second Test | 12 | 8 | 0 | 1 |
| Gp. VII–VS1 | | | | |
| First Test | 5 | 21 | 2 | 1 |
| Second Test | 11 | 18 | 0 | 0 |
| Gp. VII–VS2 | | | | |
| First Test | 14 | 23 | 3 | 2 |
| Second Test | 19 | 18 | 4 | 1 |

tion. This is consistent with the findings of Exp. VI.

Accordingly, primary attention was paid to the responses to the first test stimulus for each *S* in determining the effects of the previous shock upon responses to the ambiguous cues. It is clear that the shock of fixed intensity had no significant effect upon the responses to the first test stimuli by the *S*s of Group VII-FS. The deviation from equal response freqencies for the *S*s in Group VII-VS1, on the other hand, is significant at the .01 level (using the binomial test). In contrast, the deviation from chance responding for the *S*s in Group VII-VS2 is not significant (using the $\chi^2$ approximation since the cell frequencies are sufficiently large). To be sure the discrepancy goes in the right direction in that more *S*s gave a not-shocked response than a shocked response. But the ratio in that direction was only about 1.5 to 1 where it was more than 4 to 1 for Group VII-VS1. Assuming that the difference between groups is not merely chance, the evidence thus indicates that the extra efforts of *E* to persuade the *S*s to accept a higher level of shock decreased rather than increased the effect of the shock.

How can one account for this seemingly odd result? First, it must be remembered that seven *S*s did not accept the one milliampere increase in shock intensity during the shock adjusting trials. Presumably these seven *S*s were among those for whom the shock was most upsetting. To a certain extent at least, then, there may have been a tendency for the increase in average shock intensity for Group VII-VS2 as compared with Group VII-VS1 (9.1 vs. 8.2 milliamperes) to be associated with *S*s who were least disturbed by shock.

One other factor must also be considered. This is related to the finding that differences in the personalities of experimenters can produce differential learning effects in verbal conditioning (Binder et al., 1958). While the same *E* ran all three groups of *S*s in the present case, we note the slight increase in participation of *E* with Group VII-VS2 as compared with Group VII-VS1. While the goal was to make each *S* less self-conscious of the shock during the preliminary attempt to fix the maximum possible intensity, *E*'s increased responsiveness may have had a kind of psychotherapeutic result in ameliorating the painful effects of the shock.

The comments of the *S*s at the conclusion of the experiment as to their reasons for giving their responses are of some incidental interest. These comments indicate that the test responses were generally not "interpretive" in the sense that some writers on perception use the term: that is, there was no concomitant implicit relating of shock and response alternatives prior to naming the ambiguous stimulus. Thirteen of the total of 92 *S*s in Exp. VII related their choice of test responses to the previous shock during learning, and, of these, five actually gave shocked responses to the ambiguous cues. Among the stated reasons for test response choice are the following quotes, which are slightly paraphrased—the numbers and symbols following each quote indicate whether the *S* who made the particular statement gave two shocked (2S), two not-shocked (2NS), or one shocked and one not-shocked (1S, 1NS) responses:

Remembered them more strongly (2S)
First two learned (2NS)
Liked those stimulus words better, sounded prettier (2NS)
Paid no attention to the shock (1S, 1NS)
Looked more alike (1S, 1NS)
Easier to remember, especially JOM (1S, 1NS)

Didn't want to get shocked again (2NS)
RUX always shocked and used to saying it (2NS)
First thought of (1S, 1NS)
Both circles, means nothing, so like a blank space (2NS)
Knew it best, first one should have been JOM, I guess, because of jagged line (2NS)
Just stuck in my mind (2S)
Both were circles and therefore easier to remember (1S, 1NS)
Because these were ones shocked (2S)

Most *S*s stated that there was no reason for their particular choices, and next in order of frequency were statements indicating ease of remembering and priority of learning. Interestingly enough, and in accord with the findings in the area of verbal conditioning, most *S*s indicated during the conversation following the experiment that they were not aware of the particular pairs that were punished.

The results of this experiment, then, indicate that, when *S*s are confronted with an ambiguous situation in which a previously shocked and a previously unshocked name are appropriate, they will tend to respond with the unshocked name. This conclusion stems not only from the significant difference for Group VII-VS1, but also from the consistency of results (though insignificant) over all groups.

The effects of the shock upon acquisition during the paired associates learning trials may be seen in Figs. 9, 10, and 11. (The curves for Group VII-VS2 are somewhat curtailed since one individual made one error to a shocked stimulus in Block 19 and two errors to a not-shocked stimulus in Block 21.) Particularly noticeable is the

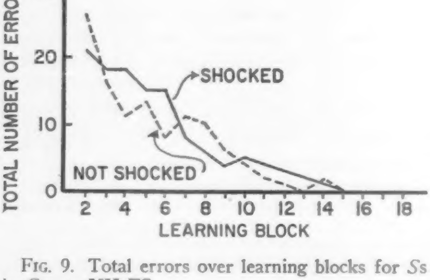


FIG. 9. Total errors over learning blocks for *S*s in Group VII-FS.

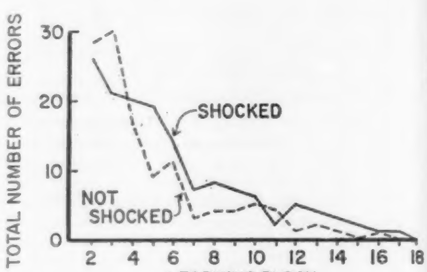


FIG. 10. Total errors over learning blocks for *S*s in Group VII-VS1.

consistent tendency for more errors to be associated with the shocked than the not-shocked stimuli from about the third to the eighth block. After approximately the eighth block (but varying between the seventh and tenth blocks for the different groups) there does not seem to be any consistent pattern. Despite the general consistency of these intervals in which more errors occur to the shocked than the not-shocked stimuli, there are obvious differences among the intervals. And these are, interestingly, related to the differences among the groups in the ratio between shocked and not-shocked responses to the test stimuli. Thus, the length of the interval for Group VII-VS1 is approximately seven blocks; that for VII-VS2, six blocks; and that for VII-FS, four blocks.

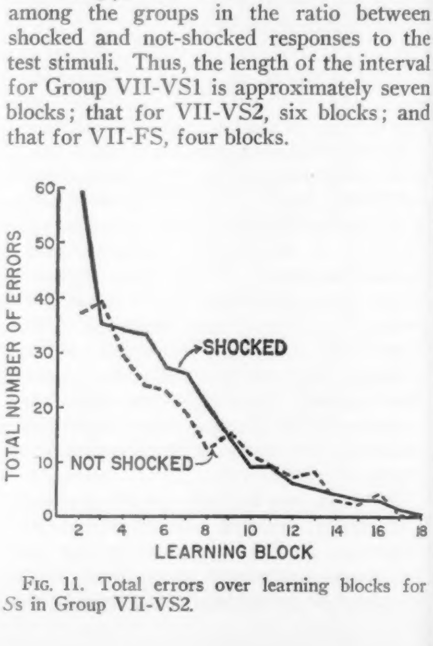


FIG. 11. Total errors over learning blocks for *S*s in Group VII-VS2.

A final comparison of some interest involves the proportion of errors, subsequent to the initial criterion of two perfect blocks, which were associated with shocked and not-shocked stimuli, respectively. These proportions and the frequencies which they represent may be seen in Table 20. The over-all difference of 38 shocked as against 19 not-shocked errors is significant at the .02 level (using $\chi^2$).

Thus, the electrical shock seemed to have some effect in interfering with the learning of the stimulus–response connections with which it was associated, as well as leading to a difference in response tendencies to ambiguous cues. There is no compelling evidence indicating that the testing differences are accountable solely on the basis of the learning differences, nor the contrary, for that matter.

## OVER-ALL DISCUSSION AND CONCLUSIONS

An immediate question that arises with respect to the frequency results is whether they are accountable on the basis of the development of response biases, rather than on the basis of recognition responses associated with particular stimuli in the previous learning trials. In other words, would comparable results have been obtained if blank cards had been shown during the test trials in place of the stimuli of reduced cues? Goldiamond and Hawkins (1958), for example, have shown that, under certain restrictive conditions, the relationship between word frequency and tachistoscopic threshold can be explained in terms of response biases. In their experiment, after a series of training trials involving the presentation of nonsense syllables at differential frequencies, *S*s were shown blank flashes at tachistoscopic speeds under instructions to respond with one of the previously learned syllables on each trial. A simulated method of limits was used. Goldiamond and Hawkins suggested that their results indicating the operation of response biases are generalizable to other types of studies establishing relationships between frequency and recognition thresholds.

TABLE 20

PROPORTIONS OF ERRORS AFTER INITIAL CRITERION IN EXP. VII

| | Shocked | Not Shocked |
|---|---|---|
| Gp. VII–FS | 70% (7) | 30% (3) |
| Gp. VII–VS1 | 66.7% (6) | 33.3% (3) |
| Gp. VII–VS2 | 65.8% (25) | 34.2% (13) |
| Total | 66.7% (38) | 33.3% (19) |

Note.—Values in parentheses give actual numbers.

There is evidence to indicate that in the present experiments the important frequency variable in determining test responses is the relative frequency of occurrence of a given stimulus under conditions in which the response in question is appropriate, and not merely the relative frequency of that response during the learning trials. First, there are the very few inappropriate responses during the test trials, which indicates that the *S*s were certainly attentive to the test stimuli. Second, the situations in which the relationship between relative frequencies during learning and relative frequencies among responses to ambiguous cues did not hold provide further evidence. Consider the *S*s in Group II-C and those in Exp. III: the relationship held with the latter but not with the former. Since the only difference in experimental conditions between the two groups was in the relative frequencies during learning (3:1:1:1 vs. 3:2:2:1), it is difficult indeed to see how the discrepancy in results between the two groups of *S*s can be explained by response biases, without stimulus considerations. (Stimulus considerations were of course essential to the explanation offered earlier for the discrepancy.) In the case of the Groups I-U and II-AB to Test Stimulus A, the discrepancy in results was associated with the presence and absence of a supplementary set of figures and names (the $C_i$'s) during learning. The source of the difficulty seemed to be a stimulus confusion between $A_1$ and $C_4$. Moreover, during learning the frequencies of the appropriate responses to the test stimuli were identical for the two groups, so response frequency per se is certainly not adequate to explain the dis-

crepancy. The $C_4$ figures and their names are somehow involved, and it is not clear how their presence or absence can affect response biases.

The third line of evidence indicating that the results of the analysis of frequency in recognition are not explainable in terms of response biases stems from considerations of the actual frequencies of the various responses during the learning trials of the *S*s in Exp. III. These particular *S*s were chosen since all possible test responses were appropriate for them and they showed almost perfect correspondence between learning and test relative frequencies. Table 21 shows the number of erroneous responses, for each block of the paired-associates trials, consisting of names occurring three times, twice, and once per block, respectively. When an erroneous anticipation was of a form which was not clearly classifiable in terms of frequency, it was not included in the analysis. Examples of responses so excluded are GAF (derived from GEP and NAF), TUX (derived from TUZ and RUX), and VAL (derived from VED and KAL). In about 25% of the cases of errors in anticipation, the *S*s gave no responses prior to the time the name appeared in the right window; these could of course not be considered in this tabulation.

TABLE 21

Classifiable Erroneous Anticipations during Learning Blocks of *S*s in Exp. III

| | Frequency of S–R Pair | | |
|---|---|---|---|
| Block | 3 | 2 | 1 |
| 2 | 14 | 65 | 31 |
| 3 | 13 | 45 | 32 |
| 4 | 10 | 29 | 15 |
| 5 | 3 | 19 | 12 |
| 6 | 3 | 11 | 6 |
| 7 | 3 | 9 | 3 |
| 8 | 0 | 3 | 1 |
| 9 | 1 | 3 | 3 |
| 10 | 0 | 2 | 0 |
| 11 | 0 | 1 | 0 |
| 12 | 0 | 1 | 0 |
| Total, Blocks 2–4 | 37 (0.48) | 139 (1.78) | 78 (1.00) |
| Total, Blocks 5–12 | 10 (0.40) | 49 (1.96) | 25 (1.00) |

If the differential frequencies of test results are explainable as response biases, these biases have surely developed during the learning trials and should be evident in the response tendencies during learning. Thus, whenever an erroneous anticipation occurs, one would expect that it is more likely to be a high frequency than a low frequency name and that this tendency will increase over the learning trials. The former is difficult to evaluate because of the complication that an *S* who responds to a stimulus figure in accord with a response bias and independently of the actual stimulus is more likely to be correct when he gives a high frequency rather than a low frequency name. But, despite this complication, if response biases are operative, the trend over learning blocks should be apparent in the proportions of erroneous anticipations for the S–R pairs of differing frequency. Table 21 shows no such trend. The numbers have been summed over blocks two to four as well as over all blocks from five on to facilitate this evaluation further. These totals are also included in Table 21; the parenthetical values are the totals in terms of the number in the right hand column as a unit. There is surely no evidence for the operation of response biases in these data.

As a final indication of the importance of stimulus factors in determining test responses we have the data on selective sampling. The *S*s in Group IV-C′-NE and those in IV-C-NE differ markedly in their proportions of various test responses, yet both groups gave the same average numbers of all of the various responses during learning. Similar comparisons may be made among other groups in Exp. IV that differed in either specific test stimulus or errors during criterion trials, but not in response frequencies during the learning trials.

Turning now to another aspect of the frequency analyses of responses to ambiguous cues: it is perhaps not unreasonable to assume on the basis of the data from groups that an individual's probability of a

given recognition response to a set of ambiguous cues will be equal to the relative frequency of his previous S–R experiences with the named stimulus object.

The findings are especially interesting when consideration is given to the deductions and empirical evidence stemming from statistical learning theory. Estes and Straughan (1954) used an experimental situation involving a given set of stimulus elements and two response classes, with respective probabilities $\pi$ and 1-$\pi$ of being reinforced. They demonstrated mathematically and empirically that asymptotic probability of response is equal to probability of reinforcement under their specified conditions. Burke and Estes (1957) later showed that statistical learning theory predicts that response probability approaches reinforcement probability regardless of the distribution of sampling parameters (Estes and Straughan had assumed them equal for all elements). Finally, Estes (1957b) has presented the most general asymptotic matching formulation, showing that cumulative response proportion tends toward cumulative reinforcement proportion no matter how the latter varies over a series of trials. Moreover, in this presentation Estes allowed any number of alternative response classes.

Since the *S*s in the present experiments were required to correct all wrong anticipations upon exposure of the response syllables, the present experiments satisfied the necessary conditions of statistical learning theory that each possible response must have an associated reinforcement which, when present on a given trial, assures that the response will terminate the trial. Using the terminology of the statistical learning theorists (see Estes, 1957b, for example), the nonsense names appearing in the right windows of the present experiments correspond to the set of reinforcing events ($E_1$, $E_2$, . . . , $E_r$), the naming responses of the *S*s to the set of alternative responses ($A_1$, $A_2$, . . . , $A_r$), and the relative frequency of occurrence per trial block for the various stimulus–response pairs to the reinforcement probabilities ($\pi_1$, $\pi_2$, . . . , $\pi_r$).

Working within the framework of statistical learning theory, Peterson (1956) used an anticipatory technique to establish two verbal response hierarchies by associating responses consisting of English nouns with pairs of nonsense syllables used as stimuli. One of the syllables in each nonsense stimulus pair was common to another stimulus pair and thus conditioned to two noun responses, while the other syllable was unique and conditioned to a single response. He found, in word association test trials involving the presentation of the ambiguous nonsense syllables (those common to two noun responses), that the observed relative frequency of response was equal to reinforcement probability (as corrected for the slight dissimilarity between learning and testing situations).

Schoeffler (1954) used test patterns composed partly of stimuli to which a given response had been conditioned, partly of stimuli to which a competing response had been conditioned, and partly of stimuli to which neither the given nor the competing response had been conditioned. His stimuli consisted of light patterns selected from a group of 24 lights, and his responses of movements of a lever to the right or left. He found that the probability of a response to a test pattern is equal to the proportion of stimulus elements in the test set that are conditioned to the response. It should be noted that Schoeffler produced ambiguity in his test stimuli by presentations containing too many cues.

The finding in the present experiments of a close correspondence between relative frequencies of presentation during learning (reinforcement probabilities) and relative frequencies of test responses provides general support for the asymptotic expectations based on statistical learning theory. However, it must be noted for the experiment involving the faces (Exp. V) that, since all cues were given 100% reinforcement, the analyses of Estes and Straughan (1954), etc. do not lead necessarily to the prediction of matching of test response and learning relative frequencies—that is, if one assumes a high degree of selective sampling such that the common elements have a comparatively low probability of being sampled. Deviations from matching would be ex-

pected to be in the direction of equal frequencies between the two alternatives (which is in accord with the results shown in Table 15). But the status of the common elements in this particular experiment is not at all clear because of their central, attention-getting characteristics.

Let us consider the other general result, namely, that *S*s who learn to make discriminating responses indicating recognition on the basis of configurations can make accurate discriminations using parts of these configurations. In only one of the six comparisons in Exp. I did the frequencies of appropriate and inappropriate responses to the test stimuli differ significantly from the frequencies expected purely as a result of the *S*s not having achieved perfect learning levels. Moreover, the results of the subsequent experiments seemed to confirm this general result.

These results of appropriate and inappropriate response frequency have important implications for conceptualization in statistical learning theory. They indicate the limitations of the approach involving component elements where stimulus events or elements are equated with cues and no allowance is made for the interaction of cues or the discriminations based upon configurations. Thus, a component approach would, in the present experiments, involve identifying various cues (circle or triangle, wavy or straight line at top, slanted line in right or left corner as in Fig. 1) or their parts as stimulus elements without assigning stimulus elements to patterning effects (such as a triangle with a wavy line above it). The stimulus elements associated with the pattern would be the stimulus elements identified separately with the components of the pattern and nothing more.

Estes (1957a) has questioned the adequacy of the component approach in statistical learning theory and pointed out the improvement in predictions resulting from considerations of pattern or configuration. In terms of the present experiment, statistical analysis of the stimulating situation based upon components leads to the prediction of many more inappropriate responses than were actually obtained. Let us demonstrate this under the assumptions that all stimulus elements had been perfectly conditioned prior to test trials and that the *S*s had learned to sample selectively early in learning. The present argument would be even stronger (though more difficult to present) without these assumptions.

Consider the stimulus elements associated with exposure of Test Figure A (see Fig. 1) in accord with a component-element approach, using Group I-E as an example. One-fourth of the stimulus events sampled in observing the triangle have been connected to the name of Figure $A_1$. One-fourth of the events have been connected to the name of $A_2$, another fourth to the name of $C_3$, and the final fourth to $C_4$. Similarly, the stimulus events associated with the line above the triangle in A have been evenly conditioned among the responses to $A_1$, $A_2$, $B_1$, and $B_2$. There would seem to be no basis for assuming that events connected with the names of $A_1$ and $A_2$ are any more likely to be sampled on a given testing trial than other events. Thus, since the probability of a given response is considered equal to the proportion of stimulus events in the population which are conditioned to the response, the probability of the name of $A_1$ to A is $\frac{1}{4}$; the name of $A_2$, $\frac{1}{4}$; either the name of $B_1$ or the name of $C_3$, $\frac{1}{4}$; and either the name of $B_2$ or the name of $C_4$, $\frac{1}{4}$. This leads to the expectation of 50% appropriate and 50% inappropriate responses to Test Stimulus A. A similar analysis may be made for Test Stimulus B for the *S*s in Group I-E. A comparable analysis for the *S*s in Group I-U involves some complications due to the unequal trial-block frequencies, but can be expected to produce similar results.

Thus, some of the results which would be predicted on the basis of a stimulus-component approach to statistical learning theory are at considerable variance with the obtained results. This clearly indicates the desirability of component interaction or, in other words, patterning considerations.

The same data also indicate the dangers in going too far in configurational emphasis. The findings on appropriate and inappropriate responses raise questions for the

gestalt interpretation of the phenomena of recognition. Thus, Koffka (1935) states:

In applying the law of similarity to the selection of a trace by a process one has to exercise great care. One must bear in mind that similarity must exist between, and therefore be defined in terms of, the process and the trace; hence similarity or partial identity between the two sets of *stimuli* which give rise to the formation of the trace and the process now occurring is *not* an adequate criterion for the application of the law. And therefore any explanation like the following one is essentially wrong: If an organism has reacted in a certain way to the stimulus complex A B C D E F, it will later respond in the same way to the recurrence of a part of this complex, say B C D. . . . We know that the response to a stimulus complex is not the sum of all responses to its individual components, but an organized pattern in which each part depends upon the organization of the whole (p. 601).

Koffka does, however, allow set or attitude much influence in producing communication between "process and trace." As an example of this he shows how, under the influence of proper set, a previously experienced figure is seen as part of the stimulus complex of a more complicated figure. Perhaps a gestalt psychologist might argue that, since the *S*s had to make discriminations on the basis of all cues in the complex, this produced an attitude which enabled them to discern and utilize the relationship between stimulus complex and stimulus part.

In summary, the results of the experiments dealing with learning frequency provide very convincing evidence of a direct relationship between learning frequency and perceptual response frequency. Moreover, these results provide a set of conditions under which the relationship breaks down. In addition, the matching of learning and recognition frequencies was useful in the investigation of selective attention in perceptual learning. It was found in this experiment that *S*s who maintain errorless responding after attaining initial criterion levels tend to respond on test trials in a manner which indicates selective attention to cues during the process of learning perceptual responses. For these individuals, common and discriminative cues among the stimuli during learning differ in their availability for association with the various responses.

Surely it is clear that a good deal of additional evidence must be accumulated before the phenomena of selective attention in recognition become clarified. Further work might also very profitably be aimed at the precise specification of the conditions under which the relationship between relative frequency of occurrence during learning and relative frequency of perceptual response does and does not hold. This would seem to have important implications not only for an analysis of such ambiguous stimulus phenomena as tachistoscopic and projective presentations, but also for statistical learning theory. Indeed, the results obtained here provide at least a partial bridge between the two areas.

The results of the experiments involving reward and punishment during learning are not as clear or compelling. Surely the indications are that shock in association with a recognition response during learning makes that response less likely to occur than another appropriate response for an ambiguous cue configuration. The experimenter's response of "Good" apparently has no comparable influence in determining responses to ambiguous cues.

An important consideration in studies on the effects of reward and punishment upon perception is the point at which the reinforcement occurs during the learning trials. Proshansky and Murphy (1942) apparently presented their rewards and punishments approximately simultaneously with their various stimuli, although the exact timing is not made clear in their article. Moreover, the *S*s made no overt responses during the training period. Schafer and Murphy (1943) report that reward and punishment came after *S* had repeated aloud the name which the experimenter had presented orally just prior to exposure of the face. The sequence in the case of the experiments of Rock and Fleck (1950) and Jackson (1954) was as follows: name told by experimenter, stimulus presented, *S* repeated name, and, finally, reward or punishment given. Apparently, Solley and Sommer (1957), however, presented the stimulus

first, then pronounced the name for the *S*, and administered reward at some time after the face appeared. No specific mention is made of whether the *S*s did or did not pronounce the names during the training series, but miscellaneous comments in their article give the impression that the *S*s did not do so. Smith and Hochberg (1954) administered shock simultaneously with the presentation of the stimuli. For the first 12 trials, the name was given to each *S* prior to each presentation, and thereafter *S* called out the name of every figure after it was shown.

The administration of reward and/or punishment after exposure of the stimulus, but prior to the response of the *S* (whether overt or not), does not seem reasonable if one is interested in the reinforcement aspects, rather than the cue aspects, of the reward and/or punishment. This is most obvious in the case where either reward or punishment is associated with one stimulus and nothing with the other stimulus of an ambiguous team. The finding of Smith and Hochberg, for example, of significantly more unshocked than shocked responses to the ambiguous test stimuli is explainable in terms of the absence of the electric shock as a cue for one of the two possible responses. One further difficulty in many of these studies is that the relationship between reward and punishment, on the one hand, and the conditions of learning, on the other, is obfuscated because the correct responses were given either prior to or immediately after exposure of the stimuli, giving the *S*s no chance for anticipation and subsequent reinforcement or correction. (There is evidence, as one might expect, that the *S*s in these experiments showed very inefficient learning, as demonstrated by enormous numbers of erroneous test responses. This is discussed by Rock and Fleck, 1950).

But associating reinforcement with response in paired-associates learning, as in the present experiments, is objectionable to those who argue that such a procedure may affect the response but not the perception. To illustrate this position, in the case of their experimental situation involving shock, Smith and Hochberg (1954) distinguish between "autism" and "inhibition of the verbal 'naming' response," and indicate that their procedure produced the autistic effect without verbal inhibition.

The problem of differentiating what is perceptual and what is purely verbal in a perceptual-type experiment has been particularly vexing to research workers in this area. One attempt at a solution to this problem has involved complete operationalism, where perception is defined in terms of the experimental conditions and recognition as the association of a correct name with a given pattern. As Estes (1959) has pointed out, the difficulty with this operational viewpoint ". . . is that, as always when one puts on blinkers, we would be in danger of failing entirely to see important aspects of the problem" (in press). However, investigators like Murphy, Schafer, Proshansky, Pastore, Smith, Jackson, Hochberg, etc. have surely not been guilty of moving too far in the direction of operationalism. In fact, some of their statements seem to indicate that a few have given perception or the "really see" process a scientific reality independent of the observations which provide its anchoring. For example, in his argument that the experimental tasks of Proshansky and Murphy (1942) were judgmental and not perceptual in nature, Pastore (1949) states:

> In order to subsume the experiment under the category of perception, the authors must demonstrate that the visual experience of the subjects is actually changed; the rewarded lines must be actually magnified in the visual experience of the subjects (p. 470).

But all investigators, regardless of theoretical persuasion, do evaluate perception experimentally by means of some recognition response under specified conditions. To be sure, other observations are sometimes made and reported to provide anchoring for a position inferring perceptual and not purely verbal processes. Thus, in support of their viewpoint that the *S*s "actually perceived" in accord with the training, Proshansky and Murphy (1942) point out that their *S*s frequently complained of the difficulty of perceiving the stimuli, that the *S*s displayed a good deal of interest in the stimuli, and that the *S*s responded carefully

and not with undue haste. Similarly, in arguing for a genuine reorganization of the perceptual field on the part of their children, Solley and Sommer (1957) state that the *S*s reported the reward-associated figure as phenomenally nearer and as having a dark line around it, producing contour emphasis.

The fact of the matter is that so little is actually known about the perceptual process and its indicators that many of the discussions on the perception vs. naming problem are purely in the realm of polemics. Current theories on the factors involved in making differential responses to stimulus configurations are quite inadequate and desperately in need of clarifying data. All investigators involved in perceptual-type research are interested in the responses of *S*s under certain rather loosely defined conditions. And, from the viewpoint of emphasis received in the literature, surely the naming or identifying response is most important. With the development and maturation of a theory, perhaps other types of responses will be equally well investigated for differentiation among higher-order constructs, but the groundwork must be firmly laid in terms of the more basic data. The experiment of Neisser (1954) is illustrative of the process of gradual elaboration of a relatively narrow perceptual concept upon the base of a well-established core. After making a rough distinction between what an *S* sees and what he says, he attempts to show that familiarity with words facilitates "seeing rather than saying the words" in tachistoscopic presentations. Defining his concepts in a very restricted fashion, he demonstrated that prior experience with words lowered the tachistoscopic thresholds for these words but not their homonyms.

The present research project has been concerned broadly with those factors in the process of learning differential responses to stimulus configurations which affect naming responses to ambiguous cue sets. In accord with most of the research in the area of perceptual processes, the test response variable studied was naming or identifying. Thus, returning to the point of departure for this particular discussion, the question of whether the response or the perception is affected by reinforcement applied during acquisition of the naming responses is not particularly meaningful at this rather crude stage of perceptual theory.

One surely gets the over-all impression from these results *in toto* of the greater significance of frequency of occurrence than of differential reward and punishment in influencing responses to ambiguous cues. The most extreme ratio of one test response to the other possible response was 21 to 5 (see Table 19) in the case of the experiments on reward and punishment, but that order of ratio was obtained repeatedly in the frequency experiments when one learning stimulus appeared four times as often as its testmate (see Tables 3, 7, and 17). Beyond that there are the precise predictions possible with learning frequency as the independent variable and the correspondence of results with the theorems of a well-formulated theory, advantages which do indeed seem to be a long way off in the case of reward and punishment.

## SUMMARY

The over-all aim of this research was to investigate the effects of variations in the conditions of learning upon responses to ambiguous stimuli. The learning consisted of trial blocks of figure–name pairs learned to a criterion by the method of paired associates. Test trials, in which the *S*s were presented with cues common to previously learned figure groups, followed the learning trials. The *S*s were instructed to respond to the ambiguous cues with the one of the previously learned names which seemed most appropriate.

The learning variable of interest in the first set of experiments was relative frequency of occurrence. Eight groups of *S*s were run in five experiments. For seven of these groups the learning figures were composed of arbitrarily chosen cues and consequently meaningless. The learning figures for these groups contained common as well as differentiating stimuli, and the test stimuli consisted of only the common cues. For the remaining group the learning figures consisted of line profiles of human faces with

the lines continued to form semicircles. The profiles were constructed in pairs having common contours, and the test stimuli consisted of these common contours in a full circle.

Among the groups whose learning figures were completely meaningless, two groups were each shown a total of eight figures per block. For one group the figures occurred at equal frequencies per block, while for the other group the frequencies per block for the various figures were (2:1) : (4:1) : (3:1:1:1) (where the parentheses show the frequencies of figures having common cues on a test trial). Three other groups in the category of those shown meaningless learning figures were shown four figures, at frequencies, respectively, of (2:1) : (4:1), (3:1:1:1), and (3:2:2:1).

The responses to the test stimuli were either consistent with the test cues, in the sense that the response names were of learning stimuli which contained these cues, or the responses were names of learning stimuli having cues which conflicted with the test cues. A hypothesis stemming from a statistical model of visual recognition was supported by the finding that the relative frequencies among the responses consistent with the ambiguous testing cues tended to equal their relative frequencies of occurrence during learning. However, there were two test stimuli for which this matching did not hold: the (2:1) test for the (2:1) : (4:1) : (3:1:1:1) group and the test for the (3:1:1:1) group. Hypotheses for these discrepancies were offered and deductions from them confirmed. Further, a second major hypothesis that the learning of discriminatory responses results in the ability to identify subsets of the learned cues was generally confirmed. Recency as an explanation for the frequency findings was ruled out.

The remaining two of the seven groups shown nonsense learning figures were used to test the hypothesis that *S*s learn to ignore selectively the nondiscriminative cues among the stimuli in a multiple discrimination situation involving recognition responses. Use was made of the finding that *S*s tend to give recognition responses to test cues at the same relative frequencies as the occurrence of these cues as components of various previously seen learning figures. The test analyses included the naming responses of one group of *S*s to a stimulus containing the cues common to all learning figures, as well as the naming responses of another group to stimuli containing both discriminative and common cues. Both groups were shown the same four learning figures equally frequently per block for the first three blocks, and then at respective frequencies of (2:1:4:1) per block throughout the remaining learning trials.

Only those *S*s who made no errors in the learning trials subsequent to the initial criterion level were used in the test of the hypothesis of the selective use of cues. Among these *S*s, those who were shown the test stimuli containing both common and discriminative cues responded with the names of figures at relative frequencies not significantly different from the relative frequencies of occurrence of these figure-name pairs during the learning trials of differential frequency of presentation. However, those *S*s who were shown the test stimuli containing only common cues responded with names at relative frequencies which differed significantly from those expected if differential learning frequencies were matched, but did not differ significantly from the frequencies expected if the common cues were selectively ignored by the fourth learning block.

The group which had the profiles as learning figures were shown four of them at frequencies of (2:1) : (4:1). The matching between relative frequencies of occurrence during learning and relative frequencies among test responses held for their first response but not for their second; lack of independence resulting from the particular nature of the stimuli was hypothesized.

The learning variables of interest in the second set of experiments were reward and punishment. Four groups of *S*s were run and four learning figures were shown to each group. The learning figures were in pairs in the sense that reward or punish-

ment was associated with one member of a given pair and no reward or punishment with the other. Reward or punishment followed response. Two test stimuli, one for the cues common to the members of each pair, were shown to the *S*s.

One group received "Good" as reward, while the other three groups received electric shock as punishment. These latter three groups differed principally in average intensity of shock. No significant difference was found between the number of responses which were previously rewarded by "Good" and the number not so rewarded. However, a tendency was found for *S*s to give test responses which were not previously shocked, at least in their first responses. The difference was significant for one group (medium shock intensity) and in the given direction for the other two.

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